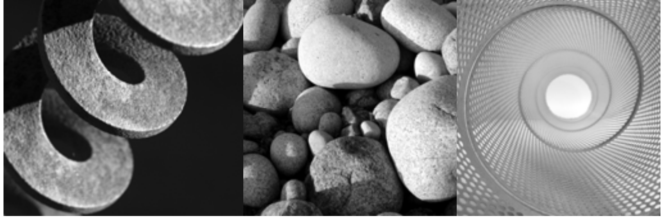


GEI Consultants

Geotechnical
Environmental and
Water Resources
Engineering

DRAFT FINAL

Coal Ash Impoundment Specific Site Assessment Report

Arizona Public Service

Cholla Power Plant

Submitted to:
Lockheed-Martin Corporation
2890 Wood Bridge Avenue
Building 209 BAYF
Edison, NJ 08837

Submitted by:
GEI Consultants, Inc.
6950 South Potomac Street, Suite 300
Centennial, CO 80112

October 2009
Project 091330

Steven R. Townsley, P.E.
Senior Project Engineer

Table of Contents

List of Tables

List of Figures and Exhibits

List of Appendices

1.0 Introduction

1.1 Purpose

This report presents the results of a specific site assessment of the dam safety of the Fly Ash Pond and Bottom Ash Pond coal combustion waste impoundments at the Arizona Public Service (APS) Cholla Power Plant in Joseph City, Arizona. The assessments were completed on September 2, 2009.

These impoundments were assessed because their failure may result in significant economic loss, environmental damage, disruption of lifeline facilities or loss of life (significant or high hazard according to U.S. Environmental Protection Agency (EPA) classification). The specific site assessment was performed with reference to Federal Emergency Management Agency (FEMA) guidelines for dam safety, which includes other federal agency guidelines and regulations (such as U.S. Army Corps of Engineers and U.S. Bureau of Reclamation) for specific issues, and defaults to state requirements where not specifically addressed by federal guidance or if the state requirements were more stringent.

1.2 Scope of Work

The scope of work between GEI and Lockheed-Martin Corporation for the site assessment is summarized in the following tasks:

1. Acquire and review existing reports and drawings relating to the safety of the project provided by the EPA and Owners.

2. Conduct detailed physical inspections of the project facilities. While on-site, fill out Field Assessment Check Lists provided by EPA for each management unit being assessed.

3. Review and evaluate stability analyses of the project's coal combustion waste impoundment structures.

4. Review the appropriateness of the inflow design flood (IDF), and adequacy of spillways or ability to store IDF, including considering the hazard potential in light of conditions observed during the inspections or to the downstream channel.

5. Review existing performance monitoring programs and recommend any additional monitoring required.

6. Review existing geologic assessments for the projects.

7. Submit draft and final reports.

1.3 Authorization

GEI Consultants, Inc. performed the coal combustion waste impoundment assessment for the EPA as a subcontractor to Lockheed Martin who is a contractor to the EPA. This work was authorized by Lockheed-Martin under the P.O. No.: 7100052068; EAC #0-381 between Lockheed-Martin and GEI Consultants, Inc. (GEI), dated June 5, 2009.

1.4 Project Personnel

The scope of work for this task order was completed by the following personnel from GEI:

Steven R. Townsley, P.E.	Senior Project Engineer/Task Leader
Mary C. Nodine, P.E.	Staff Geotechnical Engineer
Stephen G. Brown, P.E.	Project Manager
Dan Johnson, P.E.	Senior Technical Review

Program Manager for the EPA was Stephen Hoffman. Program Manager for Lockheed-Martin Corporation was Dennis Miller.

1.5 Limitation of Liability

This report summarizes the assessment of dam safety of the identified coal combustion waste impoundments at the Cholla Power Plant. The purpose of each assessment is to evaluate the structural integrity of the impoundments and provide summaries and recommendations based on engineering judgment. GEI used a professional standard of practice to review, analyze, and apply pertinent data. No warrantees, expressed or implied, are provided by GEI. Reuse of this report for any other purpose, in part or in whole, is at the sole risk of the user.

1.6 Project Datum

All elevations in this report are National Geodetic Vertical Datum (NGVD) 1929 mean sea level.

1.7 Prior Inspections

The Arizona Department of Water Resources (ADWR) inspects the Bottom Ash and Fly Ash Pond dams annually. The last ADWR safety inspection was performed on September 25 and 26, 2008. References for the reports on these inspections are provided in Section 13 of this report. In addition, an APS professional engineer performs annual inspections of the Bottom

Ash and Fly Ash Pond Dams, typically in the spring. The last independent safety inspections were performed in the summer of 2009, but the report for these inspections was not available. The reference for the previous inspection report, dated July 2008, is provided in Section 13 of this report.

2.0 Description of Project Facilities

2.1 General

The Cholla facility is a coal-fired power plant located in northeastern Arizona in the town of Joseph City in Navajo County (Figure 1). The Cholla power plant is composed of four units with a total net generating capacity of 1,027 megawatts (MW). Unit 1 was constructed in 1961, and the much larger Units 2, 3 and 4 were constructed between 1978 and 1980. Units 1, 2 and 3 are owned by APS and Unit 4, the largest unit, is owned by Pacificorp (APS, 2009 [website]). The power plant is located on the Little Colorado River.

APS Cholla has three water impoundments on site: Cholla Lake, the Sedimentation Pond and the West Area Retention Pond. Cholla Lake was originally constructed as a cooling pond for Unit 1, and currently stores water for the plant's scrubbers and provides backup cooling water if the well system primarily used for cooling the plant becomes inadequate. Cholla Lake does not contain any coal combustion waste products. The Sedimentation Pond collects water from drains located on the plant site, and receives minimal amounts of coal combustion byproducts in storm water, process water, plant water and slurry from system leaks. The West Area Retention Pond receives minimal amounts of coal combustion byproducts in storm water, process water and plant washdown from the west side of the plant. However, the Sedimentation Pond and the West Area Retention Pond are both sub-grade impoundments and do not meet the definition of a dam as set forth in the Arizona Revised Statutes 45-1202 (1), and are therefore not regulated by the state. The Sedimentation Pond and the West Area Retention Pond were not included in our Field Assessment or document review but are discussed briefly in Section 2.2. Cholla Lake was not included in this specific site assessment since it does not contain coal combustion byproducts.

In addition to the on-site impoundments, the Cholla plant has two major impoundments located off site. The Fly Ash Pond is located approximately 1.5 miles east of the plant, and the Bottom Ash Pond is located approximately two miles north of the plant. Both units have been classified as high hazard impoundments due to the potential for loss of life in the event of a dam breach because of the close proximity of the Cholla power plant, U.S. Interstate 40, a freight railroad line and several residences downstream of the dams. An overall view of the onsite and offsite ponds is shown on the aerial photograph (Figure 2).

2.2 Dams and Reservoirs

Two on-site reservoirs at the Cholla plant – the Sedimentation Pond and the West Area Retention Pond – contain minimal amounts of coal combustion waste products but are mainly intended to store water. The storage in these two ponds is below natural grade and therefore the ponds do not have dams.

The Sedimentation Pond was placed into service in 1976. It collects discharges of wastewater from an on-site secondary wastewater treatment plant, effluent from the oil/water separator, vehicle wash water from a spray wash station, plant wash water containing small amounts of coal dust and coal ash from various drainage sumps and ditches, and flue gas desulfurization wastes from scrubber or scrubber feed tank upsets. This pond has a surface area of ½ acre and a total storage capacity of 10.7 acre-feet, indicating that it is approximately 20 feet deep. The pond currently stores 0.5 acre-feet of material. Water collected in the Sedimentation Pond is pumped to the Cholla facility's General Water Sump for recycling as process water. The pond also has an overflow weir at its south end which connects to a channel that conveys flows to the West Area Retention Pond (described below). Solids are removed from the Sedimentation Pond periodically and transferred to the Bottom Ash Pond or the Fly Ash Pond. The Sedimentation Pond has a two-foot-thick compacted clay liner.

The West Area Retention pond was placed into service in 2002 to collect surface drainage. It has a surface area of ¼ acre and a total storage capacity of 4.6 acre-feet, indicating that it is approximately 20 feet deep. Currently a negligible volume of material is stored in this pond. Stored material includes stormwater, process water and plant wash-down water with minimal amounts of coal combustion byproducts from incidental discharges of process wastewater. Water collected in West Area Retention Pond is pumped to the Sedimentation Pond and recycled as process water in the Cholla Facility. The West Area Retention Pond has an earth liner.

The Cholla plant includes two large coal combustion waste dams at the two off-site impoundments. The dams included in this report are:

- Fly Ash Pond Dam
- Bottom Ash Pond Dam

The Fly Ash Pond has a total surface area of 420 acres and a storage capacity of about 18,000 acre-feet at the normal operating pool of El. 5114. Fly ash is pumped into the pond as a slurry from the Cholla plant's coal-fired generating units. The fly ash settles out of the slurry and water evaporates from the pond's surface. The Fly Ash Pond stores primarily fly ash but also contains some bottom ash, boiler slag, flue gas emission control residuals, storm water, sedimentation pond solids, boiler cleaning wastes and oil/water separator solids.

The Fly Ash Pond Dam was constructed starting in 1976 and placed into service in 1978. The dam has a crest elevation of 5120 feet giving it 6 feet of freeboard over its normal operating pool. The dam is 4,565 feet long with a maximum height of 80 feet and a crest width of 24 feet. The upstream and downstream slopes of the dam are constructed at 3H:1V.

The dam is constructed of earth fill and has a zoned cross section with a central clay core. The clay core extends to bedrock where bedrock is relatively shallow. In the central portion of the dam, where bedrock is relatively deep (greater than about 20 feet below the original ground surface), a slurry cutoff wall extends 1 foot into bedrock or 2 feet into stiff clay. In addition, there is a clay blanket extending about 250 feet from the right (west) abutment. The Fly Ash Pond Dam has no internal drain system. Where seepage has been observed, valley drains have been constructed to collect surface water and groundwater and return it to the ponds. An aerial photograph of the Fly Ash Pond is shown in Figure 3. Drawings including a plan, profile and sections of the Fly Ash Pond Dam are attached in Exhibits 1 and 2. A profile of the Fly Ash Pond Dam is attached in Exhibit 3.

The Bottom Ash Pond has a total surface area of 80 acres and a total storage capacity of about 2,300 acre-feet at the normal operating pool of El. 5117.8. The pond consists of a reservoir directly behind the dam and two coal combustion waste storage cells (the West Cell and the East Cell) upstream, as shown in the plan on Figure 4. Bottom ash is pumped into the storage cells as a slurry from the Cholla plant's coal-fired generating units. The bottom ash settles to the bottom of the pond and the water is decanted to the reservoir and ultimately siphoned back to the plant for reuse. At any given time, waste is being pumped to one of the upstream cells, and the bottom ash in the other cell is drained and excavated for storage in a monofill north of the bottom ash pond. Through this practice the total storage volume in the bottom ash pond remains relatively constant. The elevations of the intermediate dikes separating the coal combustion waste storage cells from the main reservoir are higher than that of the Bottom Ash Pond Dam downstream, and excess water from the upstream cells is drained to the main reservoir via a channel along the right abutment of the dam. The Bottom Ash Pond primarily stores bottom ash, but also contains some fly ash, boiler slag, flue gas emission control residuals, sedimentation pond effluent, sedimentation pond solids, cooling tower blowdown, oil/water separators effluent, oil/water separator solids, boiler cleaning wastes and stormwater.

The Bottom Ash Pond Dam was constructed starting in 1976 and placed into service in 1978. It was originally built with a crest at Elevation 5120. Due to an error, the pond was constructed with less storage capacity than required, and in 1993 the dam crest was raised 3.3 feet to El. 5123.3 to increase the storage capacity to required levels. The current crest elevation provides 5.5 feet of freeboard above the normal pool elevation. The Bottom Ash Pond Dam is 4,200 feet long with a maximum height of 73 feet, a 12-foot-wide crest and 3H:1V upstream and downstream slopes. The dam is constructed of earth fill and has a zoned cross section with a central clay core. The clay core extends to bedrock where bedrock is relatively shallow. In the central portion of the dam, where bedrock is relatively deep (greater than about 20 feet below the original ground surface), a slurry cutoff wall extends 1 foot into bedrock or 2 feet into stiff clay. In addition, there is a 400-foot-long slurry wall beyond the right (west) abutment of the dam. The Bottom Ash Pond Dam has no internal drain system. Where seepage has been observed, valley drains have been constructed to collect surface water and groundwater and return it to the ponds. An aerial photograph of the Bottom Ash Pond is shown in Figure 4. Drawings including a plan, profile and sections of the Bottom Ash Pond Dam are attached in Exhibit 4. A plan for the siphon system for the Bottom Ash Pond is attached in Exhibit 5. A profile of the Bottom Ash Pond Dam is attached in Exhibit 6.

Information concerning the dams at the Cholla facility is presented in Table 2.1.

Table 2.1: Cholla Power Plant - Dam Parameters Summary

Parameter	Value	
Dam	Fly Ash Pond Dam	Bottom Ash Pond Dam
Height (ft)	80	73
Length (ft)	4,565	4,200
Crest Width (ft)	24	12
Crest Elevation (ft)	5120	5123.3
Downstream Side Slopes	3H:1V	4H:1V
Upstream Side Slopes	3H:1V	4H:1V
Operating Pool El. (ft)	5118.6	5114
Normal Storage Volume (ac-ft)	18,000	2,300
Normal Surface Area (acres)	420	80

2.3 Spillways

Neither of the dams at the Cholla power plant have spillways. The dams are designed to contain the probable maximum flood (PMF).

2.4 Intakes and Outlet Works

There are no intake or outlet work structures associated with the Fly Ash Pond. Water levels are controlled by changing the pumping rate of ash slurry into the pond. Water is only removed from the pond through evaporation.

The Bottom Ash Pond has no intake structures. Water from the two upstream waste-containing cells is routed to the reservoir. Water exits the Bottom Ash Pond reservoir via a siphon system. The system consists of four 12-inch-diameter high density polyethylene (HDPE) pipes that float near the surface of the reservoir at the inlet end and extend above the top of the dam and down the downstream face to a common valve chamber and subsequent return pipe to the power plant. The pipes were originally 8 inches in diameter but have been replaced with 12-inch pipes within the past several years. The four 12-inch HDPE pipes reduce and connect to the original 8-inch pipes near the toe of the dam.

2.5 Drains

The dams at the Cholla facility were not constructed with internal drains. Since the dams' construction, however, several seepage locations have been observed and continually monitored. Valley drain and toe drain systems have been constructed at most of the seepages to collect surface and subsurface water, and typically consist of underground french drains routed to a collection sump. The water collected is returned to the Ash Ponds, and the flow rate and the quantity of seepage collected are measured. The seepage collection systems for the dams are discussed further in Section 5.

2.6 Vicinity Map

The Cholla Power Plant is located within Navajo County, Arizona in the town of Joseph City, as shown on Figure 1. The plant is located in the Southwest ¼ of Section 23, Township 18 North, Range 19 East. The Fly Ash Pond is located primarily in Section 30, Township 18 North, Range 20 East. The Fly Ash Pond is not located on or very near to a waterway. The Bottom Ash Pond is located approximately two miles north of the plant, and the Fly Ash Pond is located approximately 1.5 miles east of the plant. The Bottom Ash Pond is located at the intersection of (clockwise from top left) Sections 14, 13, 24 and 23, Township 18 North, Range 19 East. The Bottom Ash Pond is located adjacent to Tanner Wash, a tributary to the Little Colorado River that was dry at the time of our site visit.

2.7 Plans and Sectional Drawings

Engineering drawings and reports for various project features are available in the Owner's files. For reference purposes, project plan and sectional drawings from the Owner's files are reproduced in this report as follows:

Fly Ash Pond Plan	Exhibit 1 (Dwg G-557)
Fly Ash Pond Sections and Details	Exhibit 2 (Dwg G-44558)
Fly Ash Pond Embankment Alignment Profiles	Exhibit 3 (Fig. 13, Ebasco, 1975)
Bottom Ash Pond Plan and Sections	Exhibit 4 (Dwg G-44556)
Bottom Ash Pond Siphon System and Floating Pipeline	Exhibit 5 (Dwg G-556-S02)
Bottom Ash Pond Embankment Alignment Profiles	Exhibit 6 (Fig. 15, Ebasco, 1975)

2.8 Standard Operational Procedures

The Cholla facility is a coal fired power plant that provides electric power to millions of customers. The plant is composed of four units with a total net generating capacity of 1,027 MW. Coal is delivered to the power plant by trains and conveyor systems, where it is then combusted to power the steam turbines. The burning of coal produces several gases which are vented from the boiler. Bottom ash, which is made of coarse fragments, falls to the bottom of the boiler and is removed along with boiler slag. Fly ash is removed from Units 1, 3 and 4 with fabric filters. Unit 2 uses a combination of a mechanical dust collector and a venturi scrubber system (a wet particulate/SO_2 removal system) to remove fly ash.

Approximately 70 percent of the fly ash generated at the Cholla plant is sold for reuse. The remaining fly ash is pumped as a slurry along with flue gas desulfurization residuals to the Fly Ash Pond, where it settles and evaporates.

The bottom ash from the four coal-fired units is pumped as a slurry to the waste storage cells in the northern portion of the bottom ash pond. The bottom ash settles out and the remaining water is routed to the reservoir portion of the pond, in its southern portion and directly behind the Bottom Ash Pond Dam. When one waste storage cell is full, it is drained of water and the settled bottom ash is excavated and stored permanently in a monofill north of the Bottom Ash Pond. Meanwhile, bottom ash slurry is pumped into the other waste storage cell. The functions of the two waste storage cells alternate annually.

3.0 Summary of Construction History and Operation

The power plant is composed of four units with a net generating capacity of 1,027 MW. Unit 1 was constructed in 1961 and has a net capacity of 116 MW. The much larger Units 2, 3 and 4 were constructed between 1978 and 1980 and have net capacities of 260, 271 and 380 MW, respectively.

When Unit 1 was originally constructed, prior to passage of the Clean Water Act in 1972, coal combustion waste from the plant was discharged directly into the Little Colorado River. When Units 2, 3 and 4 were constructed starting in 1976, the Bottom Ash and Fly Ash Ponds were placed into service. Coal combustion waste products have since been pumped into these ponds for storage.

The Fly Ash Pond Dam was designed and constructed by Ebasco Services, Inc. starting in 1976, and it was placed into service in 1978. The embankment is zoned earth fill, with a clay core and a shell consisting of sandy random fill. The clay core extends to bedrock where bedrock is relatively shallow. In the central portion of the dam, where bedrock is relatively deep (greater than about 20 feet below the original ground surface), a slurry cutoff wall extends 1 foot into bedrock or 2 feet into stiff clay. In addition, there is a clay blanket extending about 250 feet from the right (west) abutment.

The Bottom Ash Pond Dam was designed and constructed by Ebasco Services, Inc. starting in 1976, and it was placed into service in 1978. The embankment is zoned earth fill, with a clay core and a shell consisting of sandy random fill. The clay core extends to bedrock where bedrock is relatively shallow. In the central portion of the dam, where bedrock is relatively deep (greater than about 20 feet below the original ground surface), a slurry cutoff wall extends 1 foot into bedrock or 2 feet into stiff clay. In addition, there is a 400-foot-long slurry wall beyond the right (west) abutment of the dam.

A mistake in the design calculations led to significant undersizing of the Bottom Ash Pond. The pond was originally intended to store bottom ash for 35 years but instead filled up in 13 years. In 1993, several modifications were made to the pond in order to increase storage capacity, including raising the Bottom Ash Pond Dam by 3.3 feet to its current crest elevation of 5123.3 feet and constructing intermediate ash retention dikes upstream of the Bottom Ash Pond Dam. The dikes were constructed in a configuration such that they created two ash storage cells upstream of the main reservoir cell. Surveyed plans, crest profiles and a typical section of the dikes were provided to us. The maximum operating pool elevation after the dam was raised increased from El. 5115 to El. 5118.6. However, in 1997 the flood pool allocation was reassessed and the operating level was lowered to El. 5117.8. In 1999, APS obtained a permit to store dewatered bottom ash as a monofill on the 40 acres adjacent to and upstream of the bottom ash pond.

Our assessment of the pre-construction conditions at the Fly Ash Pond and Bottom Ash Pond Dams included review of information on the design drawings. Construction reports were not available for review. The dams were constructed at the same time as Units 2, 3 and 4 at the Cholla plant. Prior to construction of the Fly Ash and Bottom Ash Ponds, coal combustion waste from Unit 1 was discharged directly into the Little Colorado River. A geotechnical report by Sergent, Hauskins and Beckwith, including subsurface explorations, was completed in 1973 prior to design and construction of the Fly Ash and Bottom Ash Ponds. There is no evidence, in the geotechnical report or otherwise, to suggest that either dam was constructed over coal combustion waste or on disturbed land. Evidence of prior releases, failures or patchwork construction were not observed during the site visit or disclosed by plant personnel during the site visit.

4.0 Geologic and Seismic Considerations

The Cholla Power Plant and its associated impoundments are located in and near the town of Joseph City in Navajo County, Arizona. This area of Arizona is within the Colorado Plateau Physiographic Province, which encompasses the southeastern half of Utah, extreme western and southwestern Colorado, northwestern New Mexico, and the northern half of Arizona. The Colorado Plateau Physiographic Province is characterized by horizontal-bedded sedimentary rock, high elevation and deep canyons. Riverbeds in this region are generally narrow and widely-spaced.

The bedrock in the Cholla Power Plant vicinity consists of several geologic units including the Coconino Sandstone, the Wupatki, Moqui and Holbrook Members of the Moenkopi Formation, the Shinarump Member of the Chinle Formation, and the Little Colorado and Wash Alluviums.

The Coconino Sandstone is of Permian age and underlies both the Bottom Ash and Fly Ash Pond Dams below about El. 4915. This formation is the oldest exposed formation in the region. The Coconino Sandstone consists of very fine to medium-grained quartz grains cemented with silicious cement. The formation is pale orange to pure white and is believed to be of eolian origin.

The Triassic-age Moenkopi Formation overlies the Coconino Sandstone. The Wupatki Member, which consists mainly of reddish brown, thin-bedded siltstone and fine-grained sandstone with thin-bedded sandstone and mudstone at its base, is the oldest member. The Moqui Member overlies the Wupatki Member and consists of pale brown to reddish-brown mudstone and siltstone beds with gypsum. The youngest member is the Holbrook Member, which is present at both abutments of the Bottom Ash Pond Dam above approximately El. 5070. The Holbrook Member consists of pale red, medium- to very fine grained well-graded sandstone with silt.

The Shinarump Member of the Triassic-age Chinle Formation is present in a channel at the right abutment of the Bottom Ash Pond Dam. The Shinarump consists of weakly- to well-cemented sandstone and conglomerate with rounded pebbles of quartz, quartzite, jasper and chert and subangular pebbles of petrified wood as well as petrified logs. At the channel adjacent to the Bottom Ash Pond Dam, the Shinarump is well-cemented and fractures easily, making it very permeable.

The Little Colorado River and Wash Alluviums overlie the bedrock and are composed of unconsolidated clay, silt, sand and gravel. The alluvium thickness ranges up to about 50 feet thick beneath the Fly Ash Pond Dam and up to about 100 feet thick beneath the Bottom Ash Pond Dam.

A peak horizontal acceleration coefficient of 0.05g was applied as a pseudo-static coefficient in the facility design. This would be generally consistent with accelerations of about 0.08g as shown on the 2008 United States Geological Survey (USGS) regional probabilistic seismic hazard map for 2 percent Probability of Exceedance within 50 years (recurrence interval of approximately 2500 years). The Maximum Considered Earthquake (MCE) loading is applicable to the design earthquake for high hazard classification impoundments based on federal dam safety guidance. A seismotechtonic study to develop the MCE has not been documented for the Joseph City area. For this assessment, application of a background, or floating, earthquake concept is employed for an assessment level check on the peak horizontal acceleration for the Joseph City area. A maximum background earthquake was established by dePolo (1994) for the Basin and Range physiographic province at a value of M 6.5 at a hypocentral depth of 15 km. An approximate range of peak horizontal acceleration for the background earthquake would be 0.15g to 0.18g based on attenuation relationships developed for the Western United States. Lacking a more detailed study, this range of acceleration will be considered for checking structural stability in this assessment.

Site-specific documentation presenting geologic information for the facilities at the Cholla Power Plant included:

- Sergent, Hauskins & Beckwith, 1973 "Preliminary Soil and Geologic Study Report on Proposed Ash Disposal Areas"
- Ebasco Services Inc. 1978 "Ash Disposal Sites Seepage and Foundation Studies"

Borings drilled at the location of the Fly Ash Pond from the Sergent, Hauskins & Beckwith (1973) and Ebasco (1978) reports indicate that the stratigraphic section includes between 0 and 30 feet of alluvium consisting mainly of silty clay with some sand and gravel. The overburden soils are underlain by claystone and siltstone with gypsum (Moqui Member of the Moenkopi Formation). Several borings near the center of the embankment encountered the Wupatki Member of the Moenkopi Formation below about 70-foot depth, which consists here of sandstone with traces of gypsum.

Borings drilled at the location of the Bottom Ash Pond for the Ebasco (1978) report indicate that the stratigraphic section includes between 0 and 90 feet of alluvium consisting mainly of sandy clay with some gravel and silt. The overburden soils are underlain by weathered claystone with some gypsum and interbedded siltstone (Moqui Member of the Moenkopi Formation). The Holbrook Formation outcrops at both abutments of the dam above the Moqui and consists of clayey sand overlying weathered sandstone and claystone A channel of the highly-permeable Shinarump Formation, which consists of well-cemented sandstone and conglomerate, was encountered near the right abutment of the Bottom ash pond dam.

5.0 Instrumentation

5.1 Location and Type

A large network of instrumentation is installed near the Fly Ash and the Bottom Ash Ponds at the Cholla facility. Several piezometers were installed in each dam at the time of construction. Additional instrumentation has been added to monitor movement, seepage quantities, water levels and water quality at specific locations. The instrumentation is monitored by APS on a regular basis.

5.1.1 Fly Ash Pond

Piezometers, movement monitoring points and seepage flow measurement totalizers have been installed on and near the Fly Ash Pond Dam. Forty piezometers are currently monitored at the Fly Ash Pond Dam. Eight piezometers were installed just beyond the downstream toe and at the right abutment at the time the dam was constructed for the purpose of monitoring water levels in the major geologic formations underlying the dam. The remaining piezometers have been installed since construction. Some of these were installed near locations where seepage has been observed, and 12 were installed in 2001 during an investigation of cracking on the dam crest. Four of the piezometers installed in 2001 measure water levels in the embankment core, and three measure water levels in the shell. The remaining five piezometers installed in 2001 and the piezometers installed prior to 2001 measure water levels in the dam foundation. The piezometers are currently monitored quarterly, except those installed in 1999 have been monitored weekly. An application to reduce the frequency of these measurements has been submitted by APS to ADWR and is currently under review, since ADWR lifted the safety deficiency it imposed on the dam before the cracking was investigated. The wells are distributed on the crest, upstream slope, downstream toe and at the abutments of the Fly Ash Pond. Several wells have been dry for at least ten years, and these are not discussed in this assessment.

Sixteen survey monuments are installed on the Fly Ash Pond Dam for the purpose of monitoring horizontal movement and settlement. Ten of these were installed at the time of dam construction, and the remaining six were installed in the area around Geronimo Knob (near the center of the dam) in 2001 as part of the investigation of cracking in the dam crest. The survey monuments are monitored annually.

Seepage is monitored at two locations at and beyond the toe of the Fly Ash Pond Dam by means of seepage totalizers. Seepage collection and monitoring systems have been installed near the Fly Ash Pond at locations where seepage has been observed in order to collect water and return it to the pond, as well as to measure the volume of water collected. Currently seepage is monitored weekly at the Geronimo Seep, located about 50 feet beyond the downstream toe and 2,000 feet from the right abutment, and quarterly at the Hunt Seep, located about 1,500 feet beyond the downstream toe. The seepage totalizers at these locations measure the seepage collected and returned to the Bottom Ash Pond, which includes water potentially originating from the pond as well as surface water and groundwater. Turbidity was measured at water collected from both the Hunt and Geronimo Seep starting in November 2001. Turbidity measurements were terminated in October 2002 for the Hunt Seep but continue to be measured for the Geronimo Seep.

5.1.2 Bottom Ash Pond

Piezometers, movement monitoring points and seepage totalizers have been installed on and near the Bottom Ash Pond Dam. A total of 46 piezometers are currently monitored on the Bottom Ash Pond Dam. Three of these piezometers were installed just beyond the downstream toe at the time the dam was constructed for the purpose of monitoring water levels in the major geologic formations underlying the dam. The remaining piezometers have been installed in the time since the dam was constructed, some of which are located at locations where seepage has been observed. The piezometers are monitored quarterly. The wells are distributed on the crest, upstream slope, downstream toe and around the perimeter of the Bottom Ash Pond.

Ten survey monuments are installed on the crest of the Bottom Ash Pond Dam for the purpose of monitoring horizontal movement and settlement. Monuments were first installed when the dam was constructed but were moved in conjunction with the 3.3-foot dam raise in 1993. The survey points are monitored annually.

Seepage is monitored at four locations at and beyond the toe of the Bottom Ash Pond Dam by means of four seepage totalizers and one weir. Seepage collection and monitoring systems have been installed near the Bottom Ash Pond at locations where seepage has been observed in order collect water and return it to the pond, as well as to measure the volume of water collected. Currently seepage is monitored quarterly at the West Abutment Seep, located about 100 feet downstream of the right abutment toe; the Tanner Wash Seep, located about 350 feet beyond the left abutment of the dam; the Petroglyph Seep, location about 150 feet beyond the dam toe on the east side; and the P-226 Seep, located about 250 feet beyond the left abutment toe. The seepage totalizers at these locations measure the seepage collected and returned to the Bottom Ash Pond, which includes water potentially originating from the pond as well as surface water and groundwater. There is also a weir at the West Abutment Seep upstream of the totalizer which measures the amount of water that daylights at the dam toe. Turbidity was measured at the seep locations from November 2001 until October 2002.

5.2 Time Versus Reading Graphs of Data

5.2.1 Fly Ash Pond Dam

Data from piezometers, movement monuments and seepage totalizers for the Fly Ash Pond Dam are provided in Appendix A.

5.2.1.1 Piezometers

Water level data for piezometers at the Fly ash pond dam were provided to us starting in 1989. Digital data were provided starting in 1996.

The water levels in the piezometers installed in the Moqui Member of the Moenkopi Formation at the dam abutments (F-100, 117, 118, 120 and 121) have remained relatively steady with time. Two piezometers at the downstream toe in the Moqui Member (F-89 and 112) have remained steady, while a third shows a steady upward trend generally consistent with the trend in the reservoir water level.

Two piezometers are installed in the Moqui and Holbrook Members of the Moenkopi Formation at the right abutment of the dam (F-81 and F-35). The water level in piezometer F-81 decreased steadily from 1989 until 1993, to El. 5064, then increased suddenly to El. 5091, which was close to the elevation of the water in the Fly Ash Pond Reservoir at that time. The water level then decreased rapidly over the course of the next year to El. 5075 and has steadily decreased ever since. The water level in piezometer F-35 was steady around El. 5070 until it became inaccessible in 2003. When it was measured again in 2007, the water level had risen to El. 5094, approximately the elevation of the reservoir water level. The water level in F-35 remains close to the reservoir water level.

Five piezometers are installed in the alluvium near the center of the Fly ash pond dam crest (F-104, 105, 108, 109 and 110). The water levels in these piezometers have remained relatively steady with time and tend to follow trends in the water level of the reservoir. The piezometers on the upstream side of the crest have water levels within 10 feet of the Fly Ash Pond water surface elevation, while those on the downstream side of the have water levels at least 30 feet below the Fly Ash Pond water surface. The piezometers in the alluvium at the downstream toe (F-106, 111, 92, 93 and W-123) have remained steady with time.

Deeper wells in the Wupatki Member of the Moenkopi Formation and in the Coconino Formation at the Fly Ash Pond Dam toe (F-88, 90 and 91 and W-124 and 125) show a general downward trend over time. Water levels in these wells have decreased about 25 feet since 1989. The APS July 2008 Dam Safety Inspection Report indicates that the decrease in water level elevation is due to fly ash buildup along the upstream toe of the dam.

The piezometers installed in 1999 (F-123 to 134) have generally been steady since at least 2001. Three of the piezometers installed in the dam core (F-123, 124 and 132) had water levels 5 to 10 feet higher than the water level in the reservoir but recently have stabilized at the reservoir water level (El. 5094). The fourth piezometer in the core (F-124) had an upward trend from 2001 to 2003 but has stabilized around El. 5089.

5.2.1.2 Survey Monuments

The monument settlement profiles have generally shown less than about 0.3 feet of settlement over the past 13 years. A maximum settlement of about 1.7 feet has occurred over the life of the dam near the maximum section. Horizontal movement has been less than 0.3 feet upstream and less than 0.4 feet downstream. Generally the right side of the dam, which is a saddle, has experienced net downstream movement, and the main portion of the dam has experienced net upstream movement.

5.2.1.3 Seepage Totalizers

Seepage measured at the Geronimo totalizer was less than 8 gallons per minute (gpm) from the start of measurements in 1993 until 2003, when readings began to vary widely. After 2003, flows as high as 47 gpm were recorded, but the 2008 APS Dam Safety Inspection Report indicates that the equipment sometimes malfunctions and some of the readings are incorrect. A similar comment is made in the 1999 APS inspection report, which indicates that the totalizers will be replaced with more reliable mechanical flow meters. The situation does not appear to have been addressed. Similarly, the Hunt Seep Totalizer generally recorded less than 2 gpm from the start of measurements in 1997 until 2005, when its readings began to vary widely with seepage quantities up to 12 gpm recorded. However, APS personnel indicated that the Geronimo Seep readings are calculated based on the Hunt Seep readings, and therefore readings for both seeps may be affected when the totalizers malfunction.

Turbidity measured in the Hunt Seep from November 2001 to October 2002 was typically less than 0.5 NTU, but isolated readings up to about 2.5 NTU were recorded. Recent readings at the Geronimo Seep have typically been less than 0.5 NTU. Isolated readings greater than 5 NTU have been recorded, but the 2008 APS Dam Safety Inspection Report attributes these readings to an equipment malfunction which has since been corrected.

5.2.2 Bottom Ash Pond Dam

Data from piezometers, movement monuments and seepage totalizers for the Bottom Ash Pond Dam are provided in Appendix A.

5.2.2.1 Piezometers

Water level data for piezometers at the Bottom ash pond dam were provided to us starting in 1989. Digital data were provided starting in 1996.

Piezometer B-221 was installed in the Alluvium and the Holbrook Member of the Moenkopi Formation in the area upstream of the Bottom Ash Pond. This piezometer was taken out of service in 2003 due to monofill activities. Prior to 2003, the water level in the piezometer had a general upward trend, rising about 10 feet over the course of 13 years.

Piezometers installed north of the pond and at the left abutment in the shallow Chinle formation (B-217, 222 and 224) showed a slight rise in water elevation between 1989 and 1999, following the trend of the Bottom Ash Pond water surface elevation. After 1999, B-217 and 224 generally followed the slight fall in elevation of the Bottom Ash Pond water surface, while B-222 rose about 10 feet in 2002 and remained steady thereafter. The elevation of the water in B-224 has always been about 10 feet higher than that of the reservoir.

Piezometers installed at the right abutment in the Chinle Formation or the Holbrook and Moqui Members of the Moenkopi Formation(B-218, 219, 220 and 223) generally follow the slight downward trend of the water surface in the Bottom Ash Pond. The water level in B-223 coincides very closely with the elevation of the water surface in the Bottom Ash Pond.

Piezometers in the alluvium and in the Holbrook Member of the Moenkopi Formation in the embankment and at the toe near the right abutment (B-202, 203, 204, 205 and 227) follow the slight downward trend of the water surface in the Bottom Ash Pond. The piezometer located on the upstream slope of the dam shows a water level about 10 feet below the water surface of the Bottom Ash Pond, while those on the downstream slope of the dam (B-203 and 205) have water levels about 50 feet below the water surface of the Bottom Ash Pond.

Piezometers in the alluvium and in the Holbrook and Moqui Members of the Moenkopi Formation at the embankment toe (B-95, 96, 200, 202, 201, 206, 207, 208B, 209, 210, 211, 212, 213, 214, 215, 216, 225, 226, 228, 229 and 230) have remained relatively steady. B-208B, 209, 211 and 212 have a slight downward trend similar to that of the water surface in the Bottom Ash Pond.

Piezometers B-94 and W-301 through W-314 are located downstream of the dam in the alluvium, the Moqui Member of the Moenkopi Formation, or the Coconino Sandstone. The water levels in these piezometers have generally remained steady over time. W-310, 311 and 313 and B-94 show a slight downward trend similar to that of the water surface in the Bottom Ash Pond. W-312 shows significant fluctuations in groundwater level, but these are attributed in the APS 2008 Dam Safety Inspection Report to slow recovery after water quality sampling.

Piezometers DM-5 and CR-1 are installed in the alluvium and monitor the water level in the Little Colorado River. These wells show a slight downward trend with time.

5.2.2.2 Survey Monuments

The monument settlement profiles typically show about 0.3 feet of settlement over the last 10 years. Monument M-14, which is near the maximum dam section, shows about 0.7 feet of settlement in the last 10 years. Horizontal movement has been less than 0.8 feet upstream and less than 0.4 feet downstream, with larger movements occurring at the monuments located on the east side of the dam. Earlier monument readings were somewhat erratic but they leveled somewhat after APS switched from a triangulation survey system to a GPS system in June of 1999.

5.2.2.3 Seepage Totalizers

The totalizer at the West Abutment seep shows a downward trend since measurements began in 1995, with flows from around 15 gpm to flows averaging about 8 gpm in the past several years. Flows measured at the weir at the West Abutment Seep have generally been 4 gpm or less since measurements began in 1996, though records from the year 2000 indicate that the weir overflowed. The flow rate at the P-226 Seep has varied widely since measurements began in 1993, with maximum flows of about 27 gpm and averaging about 13 gpm. No flow has been measured at the P-226 Seep since March of 2008. Flows at the Tanner Wash seep were less than 5 gpm when measurements began in 1996, increased to a maximum of about 15 gpm in 2004 and decreased to around 4 gpm in 2009. Flows in the Petroglyph Seep have increased steadily to around 13 gpm since measurements began in 1996.

Turbidity measured between November 2001 to October 2002 at the Bottom ash pond dam seeps was typically less than 0.5 NTU.

5.3 Evaluation

5.3.1 Fly Ash Pond Dam

The piezometers installed on and near the Fly Ash Pond Dam indicate that the groundwater in the area has not fluctuated significantly in the past 20 years, and groundwater levels generally follow the same trends as the water surface in the Fly Ash Pond. Piezometer Response Profiles presented in the June 1999 Basic Data Report (APS) indicate that water levels have increased up to about 20 feet in the piezometers that were installed at the time of construction. Piezometers located on the downstream side of the embankment have water levels significantly lower than the elevation of the water surface in the Fly Ash Pond, indicating that the dam core and cutoff wall are effectively preventing seepage through the dam. Piezometers F-81 and F-35 are the exception, as their water levels increased suddenly to match the reservoir water level in the Fly Ash Pond in 1993 and prior to 2007, respectively. The fractured Shinarump Formation is known to be present in this area, and these readings may indicate that the clay blanket at the right abutment is not effective at preventing seepage through this formation.

Movement monuments indicate that both settlement and horizontal movement of the Fly Ash Pond Dam are minor since 1993. Movements are within a normal range for a dam of this size.

The seepage totalizers at the Geronimo and Hunt Seeps show widely fluctuating readings with maximum seepage quantities up to 47 gpm at the Geronimo Seep and 12 gpm at the Hunt Seep. The Geronimo Seep is very close to the toe of the dam and therefore seepage quantities as high as 47 gpm could be of concern with regard to dam stability. APS should repair or replace the seepage totalizers as soon as possible to determine the actual quantity of seepage at the Geronimo Seep. If it is still relatively high, an investigation of the seepage origin should be undertaken and stability analyses completed in order to determine whether seepage of this magnitude could compromise dam stability. The turbidity measured in the Geronimo Seep has apparently been low since the equipment malfunction was corrected, but turbidity measurements should be closely monitored.

The Hunt Seep is far from the toe of the dam and is not considered a concern from a dam safety standpoint.

The instrumentation installed at the Fly Ash Pond Dam is thorough and considered adequate. The frequency of readings is also adequate. The totalizers at the Geronimo and Hunt Seeps should be repaired so they can again provide a reliable measure of seepage.

5.3.2 Bottom Ash Pond Dam

The piezometers installed on and near the Bottom Ash Pond Dam indicate that the groundwater in the area has not fluctuated significantly in the past 20 years, and groundwater levels generally follow the same trends as the water surface in the Bottom Ash Pond. Piezometer Response Profiles presented in the June 1999 Basic Data Report indicate that water levels have increased up to about 60 feet in the piezometers that were installed at the time of construction. Piezometers located on the downstream side of the embankment have water levels significantly lower than the elevation of the water surface in the Bottom Ash Pond, indicating that the dam core and cutoff wall are effectively preventing seepage of water through the dam. The water level in Piezometer P-222, located north of the right abutment of the Fly Ash Pond Dam, rose between 2000 and 2002 and is now close to the water level in the Bottom Ash Pond, but this is not unexpected or concerning since this piezometer is not located on the upstream side of the dam. Piezometer W-312 has fluctuated significantly, and the cause of this fluctuation should be investigated. If the well is recharging slowly because its screen is clogged, the well should be refurbished or a new one should be installed.

Movement monuments indicate that in general, both settlement and horizontal movement of the Fly Ash Pond Dam are minor and within a normal range for a dam of this size.

The West Abutment Seep is the only one of the four seeps near the Bottom Ash Pond Dam that is considered a potential concern to dam safety. The other three seeps (P-226, Tanner Wash and Petroglyph) are relatively far from the dam toe. The totalizer at the West Abutment Seep indicates moderate flow rates, though the weir, which collects only surface water originating at the dam toe, indicates very low flow rates.

The instrumentation installed at the Bottom Ash Pond Dam is thorough and generally considered adequate. The frequency of readings is also adequate. The cause of the fluctuations in groundwater at Piezometer W-312 should be investigated.

6.0 Field Assessment

6.1 General

Site visits to assess the condition of the Fly Ash Pond Dam and Bottom Ash Pond Dam at the APS Cholla Power Plant were performed on September 2, 2009 by Steven R. Townsley, P.E., and Mary C. Nodine, P.E., of GEI. John D. Mitchell, Ted Tindall, Doug Lavarnway and Sheila Chairez of APS accompanied GEI during the assessment. Conrad Spencer, Cholla Plant Manager, coordinated the APS resources including staff and plant information to facilitate the assessment.

The weather during the site visits was sunny with temperatures around 85 to 95 degrees Fahrenheit. The ground surface was dry.

Field observations are organized as follows:

- Fly Ash Pond Dam
- Bottom Ash Pond Dam

Inspection checklists are provided in Appendix B and photographs are provided in Appendix C. Sections 6.2 and 6.3 describe observations made during the assessment relative to key project features. Section 6.4 presents specific observations.

6.2 Fly Ash Pond

Field assessment of the Fly Ash Pond included driving around the pond and along the entire length of the embankment crest and toe, walking representative sections and closely investigating areas of interest. We saw no obvious signs of settlement or displacement. Several seepage locations were observed at and beyond the downstream toe of the dam. These are closely monitored by APS and are discussed further in Section 6.4.4. A general photo of the Fly Ash Pond is shown in Photo 1.

6.2.1 Embankment Crest

The embankment crest appeared to be in good condition (Photo 2). No signs of cracking or settlement were observed during the assessment. Occasional vegetation (brush) was present on the dam crest. This vegetation should be cleared in routine maintenance. Settlement monitoring points (Photo 3) and piezometers (Photo 4) are present along the dam crest.

6.2.2 Upstream Slope

The upstream slope of the bottom ash pond embankment is protected from erosion by riprap (Photo 5) and appeared to be in good condition. Some vegetation is present on the upstream slope. We observed the fly ash slurry discharge pipes on the upstream slope (Photo 6). The discharge system appeared to be in good condition.

6.2.3 Downstream Slope

The downstream slope of the embankment is protected from erosion by riprap and appeared to be in good condition, though the riprap is eroding in some areas (Photo 7). Some vegetation was present on the downstream slope. The slurry discharge pipes traversing the downstream face are shown in Photo 8.

6.2.4 Water Surface Elevations and Reservoir Discharge

The water surface in the Fly Ash Pond at the time of our site visit was El. 5093.2. The dam crest is at El. 5120. No discharge was observed at the Fly Ash Ponds.

6.3 Bottom Ash Pond

Field assessment of the Bottom Ash Pond included driving around the pond and along the entire length of the embankment crest and toe, walking representative sections and closely investigating areas of interest. We saw no obvious signs of settlement or displacement. Several seepage locations were observed at and beyond the downstream toe of the dam. These are closely monitored by APS and are discussed further in Section 6.4.4. The Bottom Ash Pond has one main reservoir (Photos 9 and 10) as well as two upstream cells used to store bottom ash slurry as well as drained bottom ash prior to its final storage in the monofill north of the pond. The east cell, which currently stores drained bottom ash, is shown in Photo 11. The west cell currently receives bottom ash slurry (Photo 12). A vortex is visible in Photo 12 where water is exiting through a pipe to be discharged in the main reservoir. The monofill is shown in Photo 13. Excess water from the two upstream cells drains to the main reservoir near the left abutment of the Bottom Ash Pond Dam (Photo 14).

6.3.1 Dam Crest

The embankment crest appeared to be in good condition (Photo 15). No signs of cracking or settlement were observed during the assessment. Occasional vegetation (brush) was present on the dam crest. This vegetation should be cleared in routine maintenance. The 3.3-foot dam crest raise that took place in 1993 is evident in Photo 16.

6.3.2 Upstream Slope

The upstream slope of the embankment is protected from erosion by riprap and appeared to be in good condition (Photo 17). Some vegetation is present on the upstream slope.

6.3.3 Downstream Slope

The downstream slope of the embankment is protected from erosion by riprap and appeared to be in good condition, though the riprap is eroding in some areas (Photo 18). Some vegetation (brush) is present on the downstream slope.

6.3.4 Water Surface Elevations and Reservoir Discharge

The water surface in the Bottom Ash Pond at the time of our site visit was El. 5111.3. The dam crest is at El. 5123.3.

Water exits the Bottom Ash Pond via four floating siphon pipes and is returned to the power plant for reuse. The siphon re-circulation system was in operation during our site visit, but we could not see any visible signs of operation since it is a closed pipe system.

6.4 Field Inspection Observations

6.4.1 Settlement

There was no obvious evidence of settlement observed during the assessment in either embankment. An investigation of cracking in the Fly Ash Pond Dam was completed in 2001, and six survey monuments were added at this time to monitor potential movement in the area of cracking. The monuments have indicated that minor settlement (about 0.2 feet in 8 years) is taking place. The cracking is located around the maximum section of the dam, where the largest magnitude of settlement has occurred over the life of the dam (about 1.7 feet). The eastern, saddle portion of the dam is adjacent to the area of cracking and this area has settled a maximum of about 0.7 feet over the life of the dam. It is, therefore, possible that differential settlement has contributed to cracking in the dam crest. However, the amount of settlement is within the range expected for a dam as large as the Fly Ash Pond Dam, and it does not appear to be a threat to dam safety.

6.4.2 Movement

There was no evidence observed during the inspection to indicate differential movement of project structures. The survey monuments installed on the Fly Ash Pond Dam crest in response to observations of cracking have not shown excessive movement in this area (see Appendix A).

6.4.3 Erosion

There was no significant erosion of the dams or abutments noted during the assessment. Some minor erosion of riprap was observed (e.g. Photo 7 of Fly Ash Pond downstream slope). Eroded riprap should be replaced.

6.4.4 Seepage

Seepage locations were observed at and beyond the downstream toes of both dams. APS monitors flow and water quality at these seepage locations, collects seepage and returns the water to the reservoirs. The seepage locations are monitored closely mainly due to environmental concerns associated with dam material entering the nearby waterways. The major seepage locations monitored by APS are described below. Signs of seepage including salt patches and tamarisk growth have been observed at other locations along the toe (e.g. Photos 19 and 20), and these minor seepage locations are observed daily for changes and to determine whether seepage collection measures should be taken.

6.4.4.1 Fly Ash Pond

I-40 Seep: The I-40 Seep is located just beyond the downstream toe of the Fly Ash Pond Dam at the right abutment. This seep does not have drain system to return water to the pond, but an evaporation pond was constructed to collect seepage in this area (Photo 21).

Geronimo Seep: The Geronimo Seep is located less than 50 feet beyond the downstream toe of the Fly Ash Pond Dam, about 2,000 feet from the right abutment. An underground french drain system and wellpoints have been installed to monitor and collect the seepage in this area (Photos 22 and 23). Relatively large flows (up to about 47 gpm) have been measured at this location, but APS indicates that the totalizer at this location has malfunctioned recently and readings may not be accurate. No flowing surface water was observed at this seep location at the time of our assessment.

Hunt Seep: The Hunt Seep is located more than 1,500 feet beyond the downstream toe of the Fly Ash Pond Dam. The previously-damp soil indicating the seep in this area is shown in Photo 24. An underground french drain system is used to monitor and collect seepage in this area. No flowing water was observed at the time of the dam assessment at this location. The

Hunt Seep is far enough from the dam that it is not considered a potential threat to dam safety.

6.4.4.2 Bottom Ash Pond

West Abutment Seep: The West Abutment Seep is located about 100 feet downstream of the Bottom Ash Pond Dam toe (Photo 25). APS monitors the flow that daylights in this area by means of a weir (Photo 26), in addition to an underground french drain system several hundred feet east along the face (Photo 27). The general West Abutment Seep area is shown in Photo 28. We observed water flowing through the weir at the time of our site visit, and a rough measurement indicated that the flow at this time was less than 2 gpm. Flows in the weir are typically 4 gpm or less, and the totalizer at this location has measured a maximum of about 16 gpm since 1996.

P-226 Seep: The P-226 Seep is located about 250 feet beyond the left abutment of the Bottom Ash Pond Dam. Seepage is collected and measured via an underground french drain system with a totalizer. No surface water was observed at this seep at the time of our assessment, and no flow has been measured at this seep since March of 2008. This seep is far enough from the dam toe and is in the area where the dam is at its lowest height, and therefore it is not considered a dam safety concern.

Tanner Wash Seep: The Tanner Wash Seep is located about 350 feet beyond the toe of the Bottom Ash Pond Dam near the left abutment. Seepage is collected and measured via an underground french drain system with a totalizer (Photo 29). Both salt patches (Photo 30) and flowing surface water (Photo 31) were observed at this seep at the time of our assessment. A maximum flow of about 15 gpm has been measured at this location since 1995. This seep is far enough from the dam that it is not considered a dam safety concern. This seep is of more environmental concern than others due to its vicinity to Tanner Wash (Photo 32).

Petroglyph Seep: The Petroglyph Seep is located about 150 feet beyond the dam toe on the east side of the dam, south of the Tanner Wash Seep. Seepage is collected and measured via an underground french drain system with a totalizer (Photo 33). Flowing surface water was observed at this seep at the time of our assessment (Photo 34). A maximum flow of about 13 gpm has been measured at this location since 1993. This seep is far enough from the dam that it is not considered a dam safety concern.

6.4.5 Leakage

We did not observe water leaking from any of the project structures.

6.4.6 Cracking

No cracking was observed in either dam at the time of our assessment. Cracking has been observed in the crests of both dams in the past, and was investigated and monitored thereafter. Because cracking is no longer visible and it has not been shown to significantly affect dam movements or seepage, it is not considered a threat to dam safety.

6.4.6.1 Fly Ash Pond Dam

We reviewed the report *Transverse Crack Evaluation and Monitoring for Flyash Pond Dam* (URS, 2001). Cracks were first observed in the crest of the Fly Ash Pond Dam in 1980. Both transverse and longitudinal cracking has been recorded since, mainly in the area near the center of the dam where the embankment turns to the north. This location is also the intersection of the main portion of the dam and a saddle portion on the left (east) side. APS and URS completed field studies in 1999 to investigate the cracking, which included excavating an exploratory trench. Thirty-one primarily transverse cracks were identified in the trench, ranging from 0.2 feet deep to more than 12 feet deep at one location. URS concluded that a likely explanation for the cracking was differential settlement of the embankment due to variable thickness of overburden, variable dam height, seepage at the transition between the slurry cutoff trench and the clay core cutoff, as well as downstream restraint of the left, saddle portion of the dam. URS also concluded that the potential for very deep cracks is small and that the predicted flow velocity through the cracks is unlikely to cause erosion.

URS recommended that APS develop a fly ash beach adjacent to the area of cracking to maintain a minimum lateral distance of 300 feet between the impounded water in the reservoir and the area of cracking. We observed a marker placed to indicate this 300-foot distance and the water in the reservoir was well beyond the marker (Photo 35). In addition, URS recommended that APS place additional survey monuments in the area of cracking, and APS did so. Movement data for these six additional monuments (M-5a, 5b, 5c 6a, 6b and 6c) are presented in Appendix A.

APS also installed 12 new piezometers (F-123 to F-134) in the vicinity of the observed cracking in 1999, at the request of ADWR. These piezometers have since been monitored weekly but, since water levels have remained stable, APS has put in a request to ADWR to reduce the frequency of monitoring. The request is currently being reviewed.

6.4.6.2 Bottom Ash Pond Dam

We reviewed the report *Test Trench Investigation of Cracks Observed on the Cholla Bottom ash pond dam* (URS 2009). The report indicated that transverse cracks were observed in the center portion of the crest of the Bottom Ash Pond Dam in October 2007 during an ADWR inspection. The cracks ranged from hairline-size to 1 inch in thickness.

URS investigated the cracking through a geophysical survey in April 2008 (performed by subcontractor AMEC Environmental) as well as a test trench completed in September 2008. The geophysical investigation is fully documented in the report *Seismic Evaluation of Potential Embankment Cracking, Bottom Ash Embankment at Cholla Power Plant* (AMEC, 2008). In addition, a visual inspection was performed by a URS engineer in April 2008 and no visible cracking was observed.

The geophysical investigation did not indicate the presence of any deep-seated cracks in the Bottom Ash Pond Dam. The data did indicate a surficial layer of low-velocity material which could indicate dessication cracking. The test trenching investigation indicated that shallow transverse and longitudinal cracks were present at the surface of the embankment. In addition, the surficial soil in which the cracks were found was drier and coarser-grained than that found deeper in the embankment. The drier, coarser soil and the cracks generally extended no more than 4 feet deep, which correlates with the 3.3-foot height of the dam raise completed in 1990. It is therefore likely that the cracking in the crest of the Bottom Ash Pond Dam is related to shrinkage of the cohesive soil placed when the dam was raised. The cracks are narrow and there is no evidence that they extend deep into the embankment. The cracks are therefore not considered a dam safety concern.

6.4.7 Deterioration

No significant deterioration of project structures was observed.

6.4.8 Geologic Conditions

The geology of the project features is as described in Section 4.0 and in the referenced reports. There have been no studies or events (landslide, earthquake, etc.) that would result in changes to the description of local geologic conditions.

6.4.9 Foundation Deterioration

No signs of foundation deterioration were observed.

6.4.10 Condition of Spillway and Outlet Works

There are no spillways at either dam, and the Fly Ash Pond has no outlet. Four siphon pipes are the only outlet for the Bottom Ash Pond, and they appear to be in good condition. The siphon pipes are shown in Photos 36 (upstream side) and 37 (downstream side). The siphon collection point, where water from the siphon pipes is combined and routed to the plant, is shown in Photos 38 and 39.

6.4.11 Reservoir Rim Stability

The reservoir rims visible did not show any evidence of landslides or shoreline instability that would threaten the safety of the dams.

6.4.12 Uplift Pressures on Structures, Foundations, and Abutments

No evidence of uplift pressure issues was observed.

6.4.13 Other Significant Conditions

The storage of dry bottom ash in the Bottom Ash Pond is at a higher elevation than the water level in the pond. The effective storage area of the pond is therefore reduced, and this situation should be monitored to determine whether the pond can safely store the design flood. This condition is discussed in detail in Section 7.2.2.

7.0 Spillway Adequacy

7.1 Floods of Record

Floods of record have not been evaluated for the ponds at the Cholla power plant.

7.2 Inflow Design Floods

Both the Fly Ash and Bottom Ash Pond Dams have been classified as high hazard structures by the ADWR. The US Army Corp of Engineers (USACE) Guidelines for dams requires that the spillways on high-hazard dams be able to store or pass the full probable maximum flood (PMF) associated with the 72-hour probable maximum precipitation (PMP). The ponds were originally designed to store at least runoff from the 100-year storm (Ebasco 1975). ADWR guidelines specify that reservoirs without spillways should have at least 3 feet of freeboard above the maximum flood pool (ADWR, 1996).

7.2.1 Determination of the PMF

The PMF based on the 72-hour PMP was estimated using Hydrometeorological Report No. 49 (NOAA, 1984). The report indicated that the 72-hour PMP is about 8.5 inches. We also checked the precipitation for the local-storm 6-hour PMP due to the small size of the drainage basins for the ponds, and found the local-storm PMP to have a 6-hour precipitation of 10.2 inches. We used 10.2 inches of precipitation to check the freeboard of the dams.

The original design report for the Fly Ash and Bottom Ash Pond Dams (Ebasco 1975) indicates that the Fly Ash Pond will collect runoff from an area of about 1,230 acres. The 10.2 inches of rainfall for the local-storm PMP will result in a flood volume of about 1,045.5 acre-feet in the Fly Ash Pond's drainage basin.

The design report (Ebasco 1975) indicates that the Bottom Ash Pond will collect runoff from an area of about 128 acres. The 10.2 inches of rainfall for the local-storm PMP will result in a flood volume of about 108.8 acre-feet in the Bottom Ash Pond's drainage basin. The feasibility study for Bottom Ash Pond modifications (Dames & Moore 1991) indicates that with an intermediate dike, the main reservoir behind the dam will collect runoff from an area of about 49 acres, for a total flood volume of about 41.7 acre-feet.

7.2.2 Freeboard Adequacy

The Fly Ash Pond does not have a spillway, and water only exits the pond through evaporation. Therefore, the pond must be able to safely store the PMF with the reservoir at its maximum storage level. Based on the Area and Capacity Curve provided in the Ebasco (1975) design report, the 1,045.5 acre-ft flood volume from the local-storm PMP would increase the elevation of the water surface in the Fly Ash Pond to about El. 5116, which leaves the dam with about 4 feet of freeboard remaining. This amount of freeboard is adequate.

The Bottom Ash Pond does not have a spillway. Water exits the pond through evaporation and via four siphon pipes for reuse at the power plant. Because the rate at which water exits the pond via the siphon pipes is slow, we assume that the pond must be able to safely store the PMF. The Bottom Ash Pond is about 80 acres in area, but this area includes the ash storage cells upstream of the main reservoir, which impound water and ash at elevations above the maximum operating level of the reservoir. The main reservoir has an area of approximately 27 acres based on hand measurements from a recent topographic survey. The total runoff volume for the main reservoir alone is approximately 41.7 acre-feet for the local-storm PMP, which results in a required flood pool of about 1.5 feet. With the maximum reservoir storage at El. 5117.8, this flood leaves about 4 feet of freeboard remaining. This amount of freeboard is adequate.

We did not evaluate the freeboard of the intermediate bottom ash storage dike. Because the configuration of this pond is in a constant state of flux, we recommend that surveys and calculations of available storage volume be completed regularly in order to determine whether the Bottom Ash Pond can safely store the design storm. If there is insufficient storage volume, operations should be modified.

The intermediate bottom ash storage dikes upstream of the main bottom ash pond dam store ash and water at a higher elevation than the maximum operating level, so there was some concern that the main reservoir would be required to store water from the upstream cells in the event of a breach of an intermediate dike. The west cell, which currently receives bottom ash slurry, has a water surface elevation of 5125.4. Notes on recent survey drawings indicate that the west cell currently contains about 3.7 acre-feet of water and the main reservoir has an estimated volume capacity of 115 acre-feet of water between its current reservoir water level at El. 5113.3 and its maximum operating level. The main reservoir can therefore currently store the bottom ash slurry while still remaining under its maximum operating level. The reservoir should be surveyed and similar calculations performed on a regular basis.

7.2.3 Dam Break Analysis

A dam break analyses and inundation map are available for the Bottom Ash Pond Dam (Stantec, 2000). The inundation map for the Bottom Ash Pond Dam reveals that a breach of this dam would cause shallow flooding of nearby I-40 bridges and high erosive velocities, 2 to 3 feet overtopping of the Atchinson Topeka & Santa Fe Railroad trestles, flooding up to 3-feet depth in much of the APS Cholla power plant complex and shallow flooding of residences and the I-40 road south of Joseph City. The inundation map was reviewed for this assessment and is considered adequate.

A dam break analysis has not been completed for the Fly Ash Pond Dam. APS personnel indicated that a dam break analysis has not been required for this dam based on ADWR inspections. The Fly Ash Pond Dam is farther from Interstate 40, the Cholla Plant and the town of Joseph City than the Bottom Ash Pond Dam, but it has significantly more storage capacity (18,000 acre-feet versus 2,300 acre-feet). The volume of water released in a failure could therefore be much greater. Analyses should be performed to investigate whether the incremental increase in impact due to a larger reservoir could make the consequences of failure more significant than those identified for the Bottom Ash Pond Dam. If so, a dam break analysis should also be performed for the Fly Ash Pond Dam and an inundation map prepared to enable evaluation of the consequences.

7.3 Evaluation

The Fly Ash Pond Dam appears to have adequate freeboard to safely store the PMF associated with the local storm 6-hour PMP as required by the USACE for high-hazard dams. The Bottom Ash Pond currently has adequate freeboard to store the PMF, but the size and shape of the pond change constantly due to the bottom ash storage procedures. The storage capacity of the Bottom Ash Pond should be monitored frequently in order to determine whether it has sufficient flood storage capacity.

8.0 Structural Stability

8.1 Visual Observations

No visible signs of instability were evident associated with the any of the dams or embankments during the September 2009 site assessments.

8.2 Discussion of Stability Analysis

The results of slope stability analyses performed for the design of the Fly Ash and Bottom Ash Pond Dams are reported in the Ash Disposal Sites Seepage and Foundation Studies (Ebasco 1975). Stability analyses were performed on one embankment section for the original design of both dams. The section analyzed corresponds with the maximum dam section and the maximum bedrock depth. The analyses were performed using the simplified Bishop Method of Slices with the computer program MIT ICES-LEASE 1. The analysis assumed a circular failure surface. The report indicates that strength parameters were obtained from laboratory tests. According to Ebasco (1975), both construction and "operating" conditions were checked, as well as the "dynamic" load case. Details of the analyses, including soil parameters selected for both static cases (construction and operating) the pseudo-static load and the assumed phreatic surface are not provided. Graphic results of the analysis with static loading are presented, and based on the soil parameters assumed the reported results appear to be for a drained (steady state seepage) analysis. The report indicates that the soil parameters reported are those that resulted in the minimum factor of safety, and therefore it is likely that the Ebasco analysis performed for undrained (end of construction) conditions was not found to be critical.

Stability analyses were performed for the Bottom Ash Pond Dam in 1991 when plans were made to modify the dam to provide additional ash storage (Dames & Moore 1991). The Dames & Moore report that we reviewed was a feasibility-level report. We did not review the final design report for the Bottom Ash Pond modifications. The analyses were performed assuming that the dam crest would be raised 5 feet, though it was ultimately raised only 3.3 feet. The analyses were performed using the slope stability computer program PCSTABL5. The program used the Modified Bishop Method of Slices for circular failure surfaces and the Modified Janbu Method for noncircular failure surfaces. Both circular and noncircular failure surfaces were checked to find the failure surface with the lowest factor of safety. Load cases analyzed included steady-state seepage and pseudo-static conditions (acceleration of 0.05g). The end of construction case was not analyzed since at the time the dam had been in place for 13 years. Analyses were performed both for a reservoir pool at El. 5120 (higher than the current allowed maximum pool of El. 5117.8) and at El. 5112 (the reservoir water level at the time the analyses were completed). The shape of the phreatic surface was estimated using readings from three piezometers distributed along the cross section of the dam. The actual elevations of the water in the piezometers was used for the analysis with a water surface at El. 5112, and the water surface was raised proportionately to create a similar piezometric surface for a reservoir water level at El. 5120. The Dames & Moore report indicates that soil parameters were obtained from a report presented by Harza (1987) which we did not review as part of this assessment. The parameters used for the analysis are generally more conservative than those assumed for the Ebasco stability analysis performed in 1975 and discussed above. However, the Dames & Moore Analysis assumes that the impounded material behind the dam consists of bottom ash with a unit weight of 85 pounds per square foot (psf) and a friction angle of 24 degrees, rather than water, which the reservoir behind the dam currently holds. This assumption is unconservative.

Soil parameters assumed for both previous analyses are presented in Table 8.1.

Table 8.1: Material Properties used for Slope Stability Analyses presented in Reviewed Reports

Material	Ebasco (1975)			Dames & Moore (1991)		
	Friction Angle, ϕ (degrees)	Cohesion, c (psf)	Unit Weight (psf)	Friction Angle, ϕ (degrees)	Cohesion, c (psf)	Unit Weight (Total/ Saturated) (psf)
Clay Core and Embankment Raise	25	2500	110	28	0	120/128
Shell	35	500	110	33	0	121/125
Foundation/ Overburden (Sand)	30	0	115	26	0	120/120
Foundation/ Overburden (Clay)	30	0	115	26	0	128/128
Bedrock	--	--	--	65	1000	150/150

In our opinion, the slope stability analyses presented in the Ebasco (1975) report are incomplete. Undrained soil parameters, pseudo-static loads and the assumed phreatic surface are not specified, and results are not presented for the end of construction or dynamic load cases. The stability analyses presented in the Dames & Moore 1991 report are more comprehensive, but these do not analyze the Bottom Ash Pond Dam in its current configuration with a 3.3-foot crest raise and a maximum pool at El. 5117.8. The Dames & Moore 1991 analyses are also unconservative due to the assumption that the dam is impounding hydraulically placed bottom ash rather than water. Neither report presents a rapid drawdown analysis. Though the case of rapid drawdown is not likely to occur for reservoirs with no outlet structures, the reservoir could be drawn down in the case of a leak or other malfunction, and the analysis is required by the Federal Energy Regulatory Commission (FERC).

To check the stability of the Fly Ash and Bottom Ash Pond embankments, we performed stability analyses for the maximum section of each dam in its current configuration using the limit equilibrium slope stability program SLOPE/W. We used Spencer's Method, which solves for both moment and force equilibrium. The initial search was for circular slip surfaces, but we used the optimization feature in SLOPE/W to check for noncircular slip surfaces (Geo-Slope, 2007). The geometry for the Fly Ash Pond Dam was the same as that analyzed in the Ebasco (1975) report, and the geometry for the Bottom Ash Pond Dam was determined using the as-built drawings, which included the 1993 dam raise to El. 5123.3. We assigned the foundation clay layer the same properties as the adjacent sand layer, which was conservative. The phreatic surfaces were determined using recent water level readings in embankment piezometers: F-124 and 113 for the Fly Ash Pond Dam, and B-205 and 206 for the Bottom Ash Pond Dam. Analyses were performed for steady-seepage, pseudo-static (coefficient of 0.08g, which is about ½ the peak acceleration as discussed in Section 4.0) and rapid drawdown load cases. The end-of-construction load case was not analyzed since the dam has been in place for several decades. We used drained soil strength parameters and unit weights as developed in the Dames & Moore (1991) analysis (see Table 3) since these parameters were more conservative than those assumed in the Ebasco (1975) analysis. Rapid drawdown analyses were performed using the three-stage analysis method available in the SLOPE/W software package, in which both drained and undrained strengths are checked at the base of each slice and the smaller strength is chosen for use in the limit equilibrium analysis at the final drawdown water level (Geo-Slope, 2007). Undrained strengths are required in this analysis in addition to drained strengths. Undrained strengths were also used for the pseudo-static analyses. The clay core is the only material in the dam expected to have significant cohesion, and its undrained strength was estimated assumed to have a cohesion of 2,500 psf cohesion as developed by Ebasco (1975) with a friction angle of zero. Undrained strengths were assigned to be the same as drained strengths for the dam shell, foundation soil and bedrock.

An intermediate dike was constructed in 1993 to divide the upstream part of the reservoir into smaller cells (East Cell and West Cell), which were created to store bottom ash, see Figure 4. The intermediate dike was constructed with a lower part that consists of hydraulically placed bottom ash and an upper part that consists of compacted bottom ash. Stability analyses were not performed for the feasibility design (Dames & Moore, 1991), but its foundation design and side slope configuration was determined based on laboratory test strengths of the bottom ash material. According to the feasibility design report, shear strength for the compacted bottom ash was developed from consolidated-undrained triaxial compression tests with pore pressure measurements, and strength parameters for hydraulically-placed bottom ash and foundation bottom ash (hydraulically-placed bottom ash beneath the dike that has been consolidated) were estimated using empirical correlations. Dames & Moore assigned an effective stress friction angle (ϕ') of 37 degrees for the compacted bottom ash and effective friction angles of 24 and 30 degrees for foundation and hydraulically-placed bottom ash, respectively. The bottom ash was assigned a unit weight of 85 psf.

The stability of the intermediate bottom ash dike constructed in 1993 is not as critical as the Bottom Ash Pond Dam, because the intermediate dike is only 4 feet higher than the Bottom Ash Pond Dam and, if the intermediate dike were to fail, the water and ash impounded by it will be contained by the Bottom Ash Pond Dam. As part of our assessment, we reviewed the stability information provided for the intermediate dike and performed a check stability analysis. A preliminary cross section of the dike is provided in the feasibility design report, and APS provided GEI with a recent survey of the Bottom Ash Pond, including profiles and a section of the dikes. The feasibility design report recommended 3H:1V side slopes for the dike, but the APS survey indicated that the dike was constructed with approximately 4.3H:1V side slopes. To evaluate the stability of the dike, GEI performed a check stability analysis for steady state seepage using the surveyed dike section and the soil parameters specified for bottom ash in the feasibility design report.

8.3 Factors of Safety

The Ebasco (1975) report indicates that the critical embankment section, which represents both the Fly Ash Pond Dam and the original Bottom Ash Pond Dam prior to its crest raise of 3.3 feet in 1993, has a minimum static factor of safety of 2.0 (we assume this analysis represents the steady seepage case) and a minimum “dynamic” factor of safety of 1.4 (we assume this analysis represents a pseudo-static earthquake load condition).

The Dames & Moore (1991) analyses for the Bottom Ash Pond Dam with a crest raise of 5 feet found minimum static factors of safety of 1.81 for the existing piezometric surface and 1.38 for the projected piezometric surface, and pseudo-static earthquake loading factors of safety of 1.52 for the existing piezometric surface and 1.38 for the projected piezometric surface. Minimum factors of safety in each load case analyzed by Dames & Moore were for non-circular failure surfaces.

We compared the reported calculated factors of safety for the Fly Ash and Bottom Ash Pond Dams, as well as the factors of safety calculated in our analyses of these dams and the Bottom Ash Pond intermediate dike, to minimum required factors of safety in accordance with FERC guidelines in Table 8.2. Values shown are the minimum factor of safety found in any of the analyses performed. Graphical results of our stability analyses are attached in Appendix D.

Table 8.2: Stability Factors of Safety for Cholla Facility Dams and Guidance Values

Loading Condition	Min. Calculated FOS, Ebasco (1975)	Min. Calculated FOS, Bottom Ash Pond Dam Crest El. 5125 (Dames & Moore 1991)	Min. Calculated FOS, Fly Ash Pond Dam (GEI)	Min. Calculated FOS, Bottom Ash Pond Dam (GEI)	Min. Calculated FOS, Intermediate Bottom Ash Dike (GEI)	Min. Required FOS (FERC)
Full Reservoir – Steady Seepage	2.0	1.6	1.67	1.71	2.1	1.5
Full Reservoir – SS with Earthquake	1.4 (0.05g)	1.3 (0.05g)	1.42 (0.08g)	1.46 (0.08g)	--	1.0
Rapid Drawdown	--	--	1.44	1.51	--	1.2

As indicated in Table 8.2, the calculated factors of safety for static and seismic conditions meet or exceed the minimum required FERC guidelines.

8.4 Seismic Stability - Liquefaction Potential

Saturated granular soils that are potentially liquefiable are not present in the dam embankment and foundation of either the Fly Ash Pond Dam or the Bottom Ash Pond Dam.

The hydraulically-placed bottom ash that comprises the lower part of the intermediate dike that divides the reservoir may be susceptible to liquefaction. The feasibility study for the Bottom Ash Pond modifications (Dames & Moore, 1991) indicates that a failure of this bottom ash slope may propagate toward the downstream toe of the intermediate dike, possibly compromising its stability. Dames & Moore recommend in 1991 that a liquefaction analysis be performed for the intermediate dike.. We did not review such an analysis, and if one was not performed, we recommend that one be completed to estimate the liquefaction potential of this material and the potential consequences of failure.

9.0 Adequacy of Maintenance and Methods of Operation

9.1 Procedures

Operations Guidelines for the APS Cholla impoundments are included in the Emergency Action Plan described in Section 10. The guidelines detail routine tasks including maintenance as well as detailed emergency procedures for a variety of potential incidents.

9.2 Maintenance of Dams

Maintenance of the dams and embankments at the Cholla facility is performed or subcontracted by APS Cholla staff. Annual inspections are made by the ADWR as well as by APS engineers. Daily inspection rounds are performed of the entire ash pond facilities by operations staff to observe the general condition of structures and embankments. Identified deficiencies are documented and repaired.

9.3 Surveillance

APS Cholla staff is responsible for the surveillance of the dams and appurtenant facilities. Monitoring of the dams instrumentation occurs monthly or quarterly. The main power plant is manned 24 hours a day and operators can respond to potential emergency situation at the dams. There are no automatic warning systems for the dams.

10.0 Emergency Action Plan

Emergency Action Plans (EAPs) were developed for both the Fly Ash and Bottom Ash Pond dams in 2001, and the plans were revised in 2006. The purpose of the EAPs is to provide notice to protect the public and notify appropriate agencies in case of potential flooding downstream from the dams. It also includes Operations and Maintenance procedures designed to identify and mitigate conditions that may compromise the dam and lead to failure.

The Fly Ash Pond Dam and the Bottom Ash Pond Dam were both classified (ADWR Inspection Report, 2009)) as High Hazard dams due to the high potential for loss of life and extensive property damage in the event of a failure.

11.0 Conclusions

11.1 Assessment of Dams

11.1.1 Fly Ash Pond

- The seepage totalizer at the Geronimo seep has measured relatively large flow rates (up to 47 gpm), and readings have varied widely in the past several years. The 2008 APS inspection report indicates that the totalizer is malfunctioning.

- Piezometers F-81 and F-35, which measure water levels in the Shinarump formation at the right abutment, have both had water levels equal to that of the reservoir in recent years. These results indicate that there is some seepage from the reservoir into the Shinarump formation in this area.

- The Fly Ash Pond Dam has about 4 feet of freeboard to store the local-storm PMP, which is greater than the 72-hour PMP.

- No dam break analysis has been completed for the Fly Ash Pond Dam despite the fact that it has nearly eight times the storage capacity of the Bottom Ash Pond Dam.

- Minor eroded riprap was observed on both the upstream and downstream faces of the dam.

- Moderate quantities of vegetation were observed on the upstream and downstream slopes, and a small amount of vegetation was observed on the dam crest.

11.1.2 Bottom Ash Pond

- Moderate quantities of seepage (up to 15 gpm) have been measured at the West Abutment Seep totalizer. Seepage quantities measured at the weir have been small.

- Readings in piezometer W-312, located near the dam toe, have fluctuated significantly. APS indicates this may be due to the piezometer recharging slowly after groundwater quality sampling.

- The main reservoir of the bottom ash pond has about 4 feet of freeboard above the maximum allowable storage elevation to store the local-storm PMP, which is greater than the 72-hour PMP.

- The Bottom Ash Pond has intermediate dikes that are higher than the main dam. These dikes store water and bottom ash at higher elevations that that of the main reservoir, and excess water drains into the reservoir. The flood storage capacity of the Bottom Ash Pond Dam depends on the quantity and topography of material in the upstream cells and is constantly changing.

- The susceptibility of hydraulically-placed bottom ash to liquefaction has not been evaluated. The intermediate dikes in the Bottom Ash Pond have been founded on consolidated, hydraulically-placed bottom ash.

11.1.3 Stability Analysis (Adequacy of Factors of Safety)

Factors of safety calculated in the original dam design, in the design of the Bottom Ash Pond raise, and in check analyses performed by GEI, exceed the minimum FERC recommended factors of safety for each of the load cases.

11.1.4 Stress Evaluation

Stress evaluation is not applicable to the dams at the Cholla facility because there are no structural elements or buildings that would warrant a stress evaluation.

11.1.5 Spillway Adequacy

The Fly Ash and Bottom Ash Pond Dams do not have spillways and are designed to store the design flood. Currently the freeboard on both dams is adequate to store the 72-hour PMF and the local-storm PMF.

The flood storage capacity of the Bottom Ash Pond Dam varies depending on the quantity and topography of the material stored in the two cells behind the intermediate dikes, upstream of the main dam.

11.2 Adequacy of Instrumentation and Monitoring of Instrumentation

The quantity of instrumentation and frequency of monitoring for the ponds at the Cholla facility are both adequate. Several instruments, including the totalizer at the Geronimo Seep and piezometer W-312, may be malfunctioning. These instruments should be repaired or replaced, if necessary.

11.3 Adequacy of Maintenance and Surveillance

The dams and embankments and the APS Cholla facility have satisfactory maintenance and surveillance programs.

11.4 Hazard Classification

The Fly Ash Pond Dam was classified (ADWR Inspection Report, 2009)) as a High Hazard dam due to the high potential for loss of life and extensive property damage in the event of a failure. We consider this hazard classification as appropriate.

The Bottom Ash Pond Dam was classified (ADWR Inspection Report, 2009)) as a High Hazard dam due to the high potential for loss of life and extensive property damage in the event of a failure. We consider this hazard classification as appropriate.

Both the Sedimentation Pond and the West Area Retention Pond store water and a minimal amount of waste below the natural grade. These impoundments do not have dams and, therefore, are not classified by the State of Arizona. Based on the small size of these impoundments and the fact that spilling of the impounded material is very unlikely because they are sub-grade structures, we consider these ponds to have a Less-than-Low Hazard Potential according to EPA standards.

12.0 Recommendations

12.1 Corrective Measures for the Structures

12.1.1 Fly Ash Pond

1. The seepage totalizer at Geronimo Seep should be repaired or replaced so reliable readings of flow rates at this location, and at the Hunt Seep location, can be obtained.

2. Flow rates at the Geronimo Seep should be monitored closely when the totalizer is fixed. If flows at this location continue to be much higher than has typically been measured at other seepage totalizers around the dams (above about 20 gpm), action should be taken to examine possible causes of seepage and investigate whether this seepage could be compromising dam stability.

3. Piezometers F-81 and F-35, which measure water levels in the Shinarump formation at the right abutment, have both had water levels equal to that of the reservoir in recent years. These results indicate that there is some seepage from the reservoir into the Shinarump formation in this area. Analyses should be performed to evaluate potential effects of seepage in this area on dam stability.

4. The potential increase in dam failure consequences due to the larger storage capacity of the Fly Ash Pond compared to the Bottom Ash Pond should be considered to determine whether a separate dam break analysis and inundation map should be completed for the Fly Ash Pond Dam.

5. Riprap should be replaced or redistributed in areas where it has eroded.

6. Vegetation on both dam slopes and on the crest should be removed during routine maintenance.

12.1.2 Bottom Ash Pond

1. Piezometer W-312 should be investigated to determine whether its erratic readings are due to slow recharge and, if so, whether recharge is slow due to low permeability of the formation or a clogged well screen. The well should be rehabilitated if necessary. If the erratic readings are found to represent the actual water levels at this location, then APS should investigate what is causing the groundwater to fluctuate and whether the fluctuations could have an effect on dam safety.

2. The Bottom Ash Pond should be surveyed regularly in order to determine its flood storage capacity. The storage volume should be calculated each time the geometry of

the cells are reconfigured, when operations change, or at a minimum every five years. If the storage is found to be insufficient to store the PMF with the required freeboard, then operations should be modified to attain the required storage capacity as quickly as possible.

3. A liquefaction analysis of the hydraulically-placed bottom ash that comprises the lower part the intermediate dike, which divides the reservoir, should be performed to determine whether failure of the intermediate dike or adjacent bottom ash slopes are likely in the event of an earthquake.

4. Riprap should be replaced or redistributed in areas where it has eroded.

5. Vegetation on both dam slopes and on the crest should be removed during routine maintenance.

12.2 Corrective Measures Required for Maintenance and Surveillance Procedures

None.

12.3 Corrective Measures Required for the Methods of Operation of the Project Works

None.

12.4 Any New or Additional Monitoring Instruments, Periodic Observations, or Other Methods of Monitoring Project Works or Conditions That May Be Required

None.

12.5 Acknowledgement of Assessment

I acknowledge that the management unit(s) referenced herein was personally inspected by me and was found to be in the following condition **(select one only):**

SATISFACTORY

FAIR

POOR

UNSATISFACTORY

SATISFACTORY
No existing or potential management unit safety deficiencies are recognized. Acceptable performance is expected under all applicable loading conditions (static, hydrologic, seismic) in accordance with the applicable criteria. Minor maintenance items may be required.

FAIR
Acceptable performance is expected under all required loading conditions (static, hydrologic, seismic) in accordance with the applicable safety regulatory criteria. Minor deficiencies may exist that require remedial action and/or secondary studies or investigations

POOR
A management unit safety deficiency is recognized for any required loading condition (static, hydrologic, seismic) in accordance with the applicable dam safety regulatory criteria. Remedial action is necessary. POOR also applies when further critical studies or investigations are needed to identify any potential dam safety deficiencies.

UNSATISFACTORY
Considered unsafe. A dam safety deficiency is recognized that requires immediate or emergency remedial action for problem resolution. Reservoir restrictions may be necessary.

I acknowledge that the management unit referenced herein:

Has been assessed on September 2, 2009

Signature: ____________________________________

List of Participants:

Steve Townsley, P.E.	GEI Consultants, Inc.
Mary Nodine, P.E.	GEI Consultants, Inc.
John D. Mitchell, P.E.	APS
Ted Tindall, P.E.	APS
Doug Lavarnway	Cholla Power Plant
Conrad M. Spencer	Cholla Power Plant
Sheila Chairez	Cholla Power Plant

13.0 References

AMEC Earth & Environmental, Inc., 2008, “Seismic Evaluation of Potential Embankment Cracking: Bottom Ash Embankment at Cholla Power Plant,” July.

Arizona Department of Water Resources, 1996, “Flood Protection for Dams with No Spillways,” April.

Arizona Department of Water Resources, 2009, “Cholla Bottom Ash Pond (09.27) September 2008 Dam Safety Inspection Report,” February.

Arizona Department of Water Resources, 2009, “Cholla Flyash Pond (09.28) September 2008 Dam Safety Inspection Report,” February.

Arizona Public Service (APS), 1975, Ash Disposal System Drawings; G-44557, G-44558, G-44556, G-556-S02.

Arizona Public Service, 1991, “Cholla S.E.S. Units 1-4 Bottom Ash Disposal Study,” May.

Arizona Public Service (APS), 1993, BA/FA Ponds Seepage Intercept System Drawings; G-114438, Sheet 1.

Arizona Public Service (APS), 1999, “Cholla Power Plant Ash Ponds and Cooling Pond: Annual Dam Safety Inspection Report,” June.

Arizona Public Service (APS), 1999, “Cholla Power Plant Ash Ponds and Cooling Ponds: June 1999 Basic Data Report.”

Arizona Public Service (APS), 1999, Fly Ash Pond Embankment Monitoring Drawings; G-145746, Sheets 1 and 2.

Arizona Public Service (APS), 2008, “Cholla Power Plant Ash Ponds and Cooling Pond: Annual Dam Safety Inspection Report,” July.

Arizona Public Service (APS), 2008, “Cholla Power Plant Ash Ponds and Cooling Ponds: June 2008 Basic Data Report.”

Arizona Public Service, 2009, “About APS” http://www.aps.com/general_info/AboutAPS_18.html.

Arizona Public Service (APS), 2009, “Cholla Generating Station Bottom Ash Pond (#09.27) Test Trench Investigation of Cracks Observed on the Cholla Bottom ash pond dam,” February.

Dames & Moore, 1991, “Consulting Engineering Services, Bottom Ash Disposal Study: Cholla Generating Station,” May.

Ebasco, Inc., 1975, “Arizona Public Service Company: Cholla Generating Station Ash Disposal Sites, Seepage and Foundation Studies,” December.

Federal Emergency Regulatory Commission (FERC), 1991, Engineering Guidelines for the Evaluation of Hydropower Projects, April.

Geo-Slope International Ltd., 2007, Stability Modeling with SLOPE/W 2007, May.

NOAA National Weather Service, 1984, “Hydrometeorological Report No. 49.”

Sergent, Hauskins & Beckwith, 1973, “Preliminary Soil and Geologic Study Report: Proposed Ash Disposal Areas, APS Cholla Plant,” December.

Stantec Consulting, Inc., 2000, “APS Cholla Dambreak Study,” November.

URS, 2001, “Transverse Crack Evaluation and Monitoring for Flyash Pond Dam, Arizona Public Service, Cholla Power Plant, Joseph City, Arizona,” October.

U.S. Army Corps of Engineers (USACE), 2009, “Colorado Plateau Physiographic Province,” http://www.agc.army.mil/publications/ifsar/lafinal08_01/five/5.1.5_frame.htm

U.S. Geological Survey, 2008, Documentation for the 2008 Update of the United States National Seismic Hazard Maps.

Figures and Exhibits

Assessment of Dam Safety of Coal Combustion Waste Impoundments at APS Cholla	GEI Consultants	SITE VICINTIY MAP
Lockheed-Martin Corporation Edison, NJ	Project 091330	October 2009 Figure 1

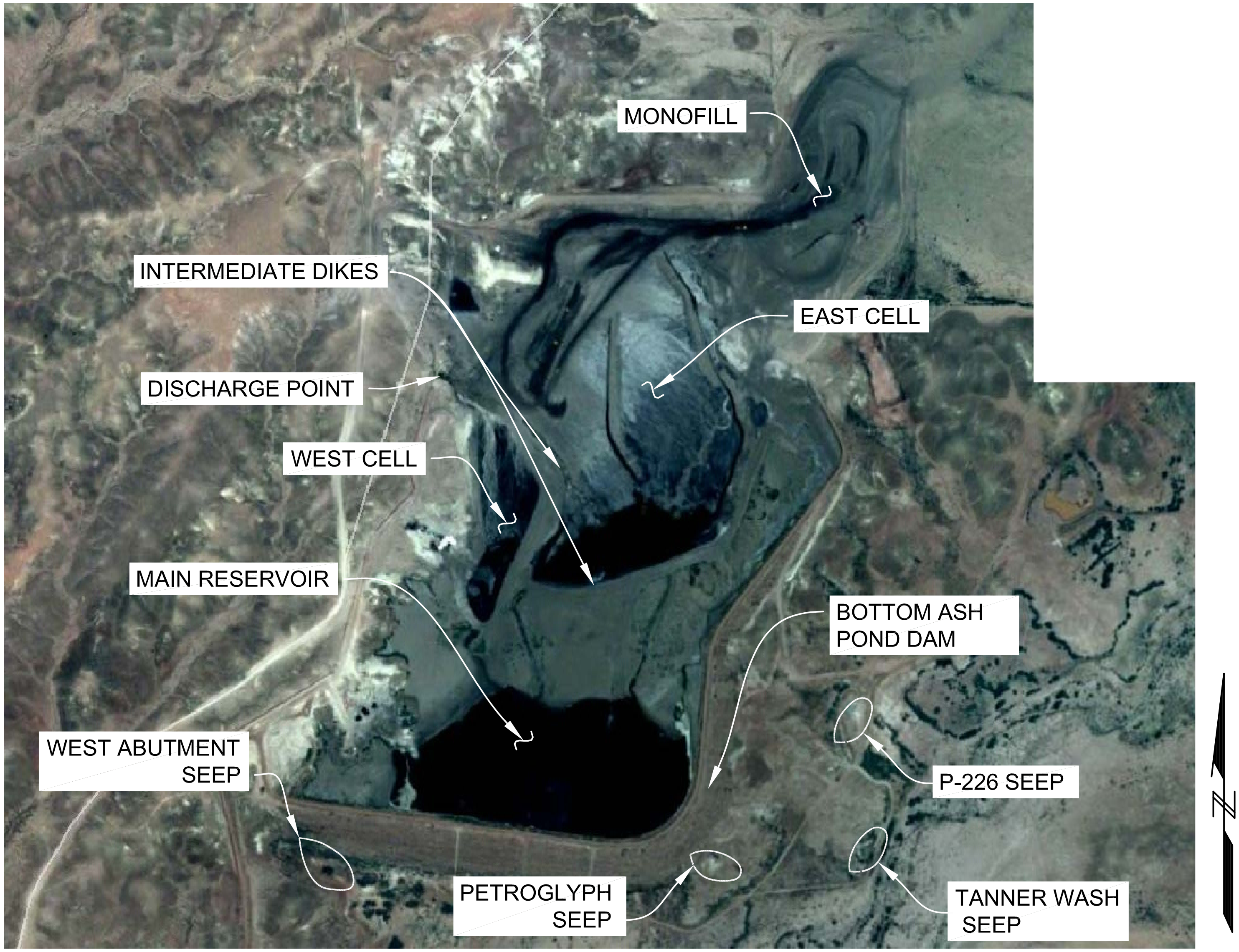
P:\091330 - Lockheed Martin Coal Ash Impoundments\APS Cholla\Figures\ FIGURE 1 SITE VICINITY MAP.dwg Oct 2009

Assessment of Dam Safety of Coal Combustion Waste Impoundments at APS Cholla	GEI Consultants	SATELLITE PHOTO
Lockheed-Martin Corporation Edison, NJ	Project 091330	October 2009 Figure 2

P:\091330 - Lockheed Martin Coal Ash Impoundments\APS Cholla\Figures\ FIGURE 2 SATELLITE MAP.dwg Oct 2009

Assessment of Dam Safety of Coal Combustion Waste Impoundments at APS Cholla	GEI Consultants	FLY ASH POND PLAN VIEW
Lockheed-Martin Corporation Edison, NJ	Project 091330	October 2009 Figure 3

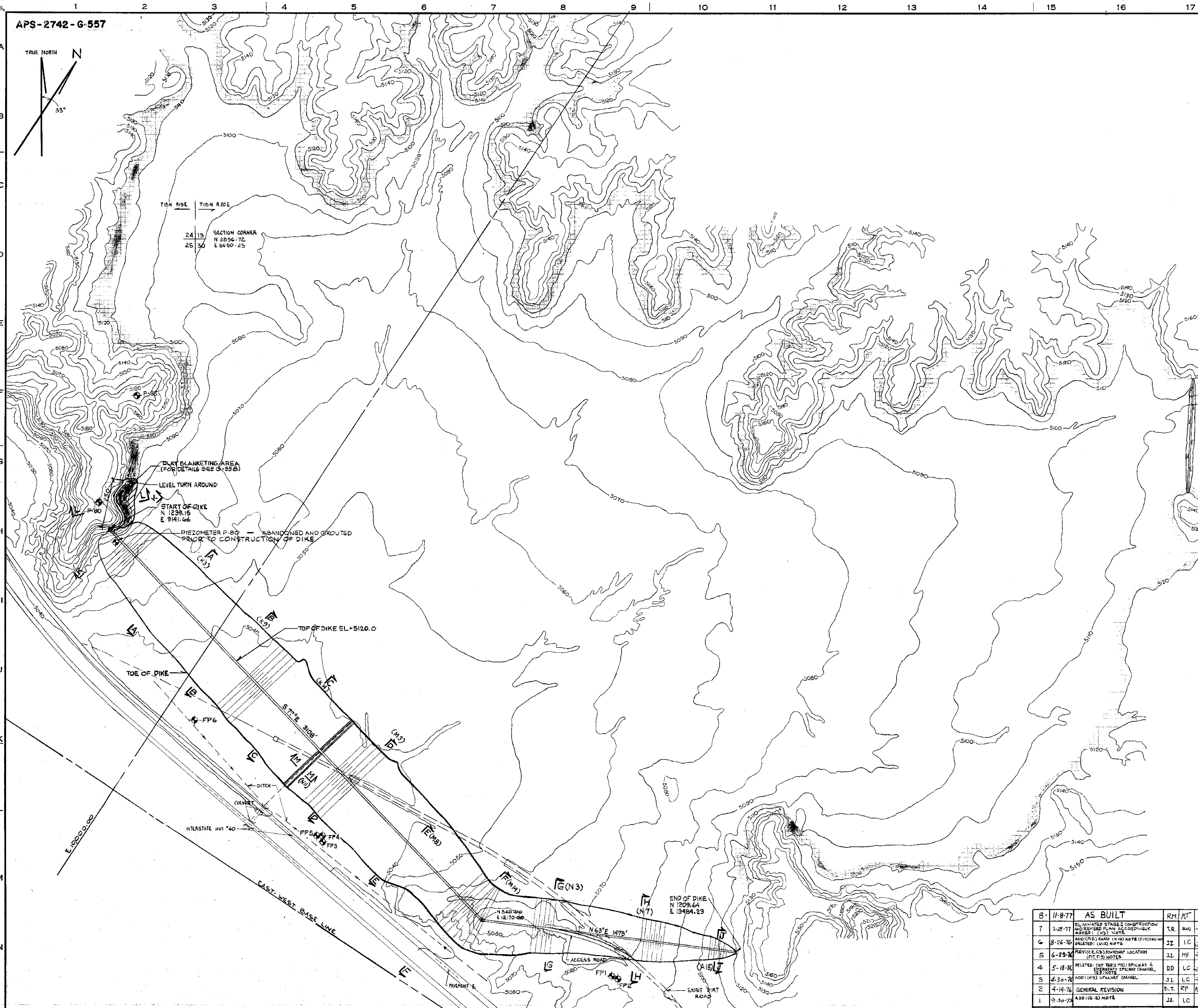
P:\091330 - Lockheed Martin Coal Ash Impoundments\APS Cholla\Figures\ FIGURE 3 FLY ASH POND.dwg Oct 2009

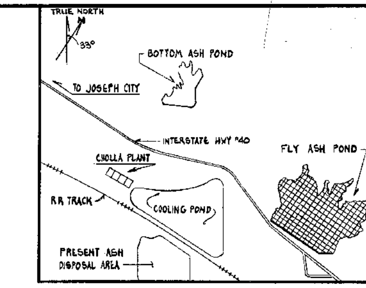


Assessment of Dam Safety of Coal Combustion Waste Impoundments at APS Cholla	GEI Consultants	BOTTOM ASH POND PLAN VIEW
Lockheed-Martin Corporation Edison, NJ	Project 091330	October 2009 Figure 4

P:\091330 - Lockheed Martin Coal Ash Impoundments\APS Cholla\Figures\ FIGURE 4 BOTTOM ASH POND.dwg Oct 2009

APS-2742-G-557





KEY PLAN

NOTES

SECTION CORNER AT (C2) IS AT JUNCTION OF TOWNSHIP 18N AND RANGE 19E AND TOWNSHIP 18N AND RANGE 20E

FOR ADDITIONAL NOTES SEE DRAWING G-556 & G-558

FOR QUANTITIES SEE DRAWING G 558

FOR PIEZOMETER DETAILS SEE DRAWING G 556

FOR ASH DISCHARGE PIPE DETAILS SEE DRAWINGS G-632 AND G-633

FOR LOCATION OF NEW PIEZOMETERS SEE DRAWING SK-CH-J20

LEGEND

DENOTES EXISTING PIEZOMETER

REFERENCE DRAWINGS

CHOLLA FLY ASH POND SITE
KENNEY AERIAL MAPPING INC PHOENIX, ARIZONA G-44248 SH 1

WORK THIS DRAWING WITH G-558

NO.	DATE	REVISION	BY	CH.	APPROVED		
8	11-8-77	AS BUILT	R.M.	M.T.			
7	2-28-77	ELIMINATED STAGE I CONSTRUCTION AND REVISED PLAN ACCORDINGLY. ADDED: (H3) NOTE	T.R.	EW	—		
6	8-26-76	ADD: (M8) ROAD (N10) NOTE (F19) DWG NO DELETED: (N12) NOTE	J.I.	LC			
5	6-29-76	REV: (C2, C3) TOWNSHIP LOCATION (F17, F19) NOTES	J.I.	MF			
4	5-18-76	DELETED: (N7 THRU M10) SPILLWAY & EMERGENCY SPILLWAY CHANNEL, (G5) NOTE	D.D.	LC			
3	4-30-76	ADD: (N9) SPILLWAY CHANNEL	J.I.	LC			
2	4-14-76	GENERAL REVISION	D.T.	RP			
1	9-30-75	ADD: (G18) NOTE	J.I.	LC			

ANDREW ANTHONY FERLITO No. 7421
Registered Professional Engineer (Civil) CERTIFICATE NO. 9161 STEPHEN I. CSIBOR DATE SIGNED 8-19-75 Arizona, U.S.A.

ARIZONA PUBLIC SERVICE COMPANY
CHOLLA S.E. STATION
1977 - 250 MW INSTALLATION - UNIT No. 2
1978 - 250 MW EXTENSION - UNIT No. 3

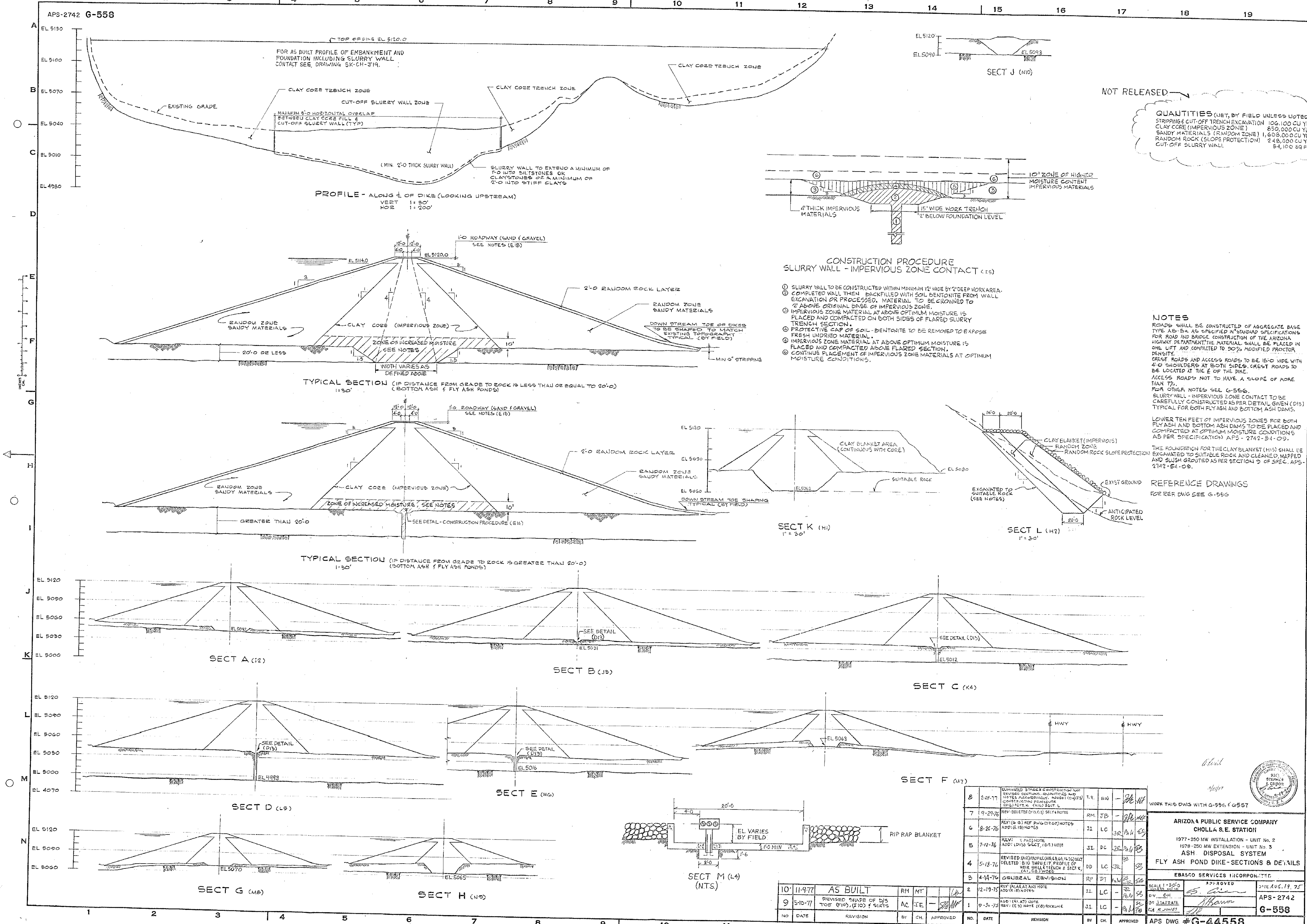
ASH DISPOSAL SYSTEM
FLY ASH POND - PLAN

EBASCO SERVICES INCORPORATED

SCALE 1" = 200'
APPROVED
DATE AUG. 19, 75
DIV. C-H
DR. G.H. J.I.
CH. R JONES
APS-2742
G-557

APS DWG. #G-44557

Exhibit 1-4



APS-2742 G-558
TOP OF DIKE EL 5120.0
FOR AS BUILT PROFILE OF EMBANKMENT AND FOUNDATION INCLUDING SLURRY WALL CONTACT SEE DRAWING SK-CH-J19.
CLAY CORE TRENCH ZONE
CUT-OFF SLURRY WALL ZONE
EXISTING GRADE
MINIMUM 5'-0 HORIZONTAL OVERLAP BETWEEN CLAY CORE FILL & CUT-OFF SLURRY WALL (TYP)
(MIN. 2'-0 THICK SLURRY WALL)
SLURRY WALL TO EXTEND A MINIMUM OF 1'-0 INTO SILTSTONES OR CLAYSTONES OR A MINIMUM OF 2'-0 INTO STIFF CLAYS
PROFILE - ALONG ℄ OF DIKE (LOOKING UPSTREAM) VERT 1:30' HOR 1:200'
EL 5130
EL 5100
EL 5070
EL 5040
EL 5010
EL 4980
SECT J (N10)
EL 5120
EL 5090
EL 5093
NOT RELEASED
QUANTITIES (NET, BY FIELD UNLESS NOTED)
STRIPPING & CUT-OFF TRENCH EXCAVATION 106,100 CU YD
CLAY CORE (IMPERVIOUS ZONE) 850,000 CU YD
SANDY MATERIALS (RANDOM ZONE) 1,608,000 CU YD
RANDOM ROCK (SLOPE PROTECTION) 248,000 CU YD
CUT-OFF SLURRY WALL 54,100 SQ FT
10' ZONE OF HIGHER MOISTURE CONTENT IMPERVIOUS MATERIALS
4' THICK IMPERVIOUS MATERIALS
15' WIDE WORK TRENCH 2' BELOW FOUNDATION LEVEL
CONSTRUCTION PROCEDURE
SLURRY WALL - IMPERVIOUS ZONE CONTACT (I5)
1. SLURRY WALL TO BE CONSTRUCTED WITHIN MINIMUM 12' WIDE BY 2' DEEP WORK AREA.
2. COMPLETED WALL THEN BACKFILLED WITH SOIL BENTONITE FROM WALL EXCAVATION OR PROCESSED. MATERIAL TO BE CROWNED TO 2' ABOVE ORIGINAL BASE OF IMPERVIOUS ZONE.
3. IMPERVIOUS ZONE MATERIAL AT ABOVE OPTIMUM MOISTURE IS PLACED AND COMPACTED ON BOTH SIDES OF FLARED SLURRY TRENCH SECTION.
4. PROTECTIVE CAP OF SOIL-BENTONITE TO BE REMOVED TO EXPOSE FRESH UNDRIED MATERIAL.
5. IMPERVIOUS ZONE MATERIAL AT ABOVE OPTIMUM MOISTURE IS PLACED AND COMPACTED ABOVE FLARED SECTION.
6. CONTINUE PLACEMENT OF IMPERVIOUS ZONE MATERIALS AT OPTIMUM MOISTURE CONDITIONS.
1'-0 ROADWAY (SAND & GRAVEL) SEE NOTES (E18)
EL 5114.0
EL 5120.0
2'-0 RANDOM ROCK LAYER
RANDOM ZONE SANDY MATERIALS
CLAY CORE (IMPERVIOUS ZONE)
ZONE OF INCREASED MOISTURE SEE NOTES
DOWN STREAM TOE OF DIKES TO BE SHAPED TO MATCH EXISTING TOPOGRAPHY TYPICAL (BY FIELD)
20'-0 OR LESS
WIDTH VARIES AS DEFINED ABOVE
MIN 6" STRIPPING
TYPICAL SECTION (IF DISTANCE FROM GRADE TO ROCK IS LESS THAN OR EQUAL TO 20'-0) (BOTTOM ASH & FLY ASH PONDS) 1:30'
ZONE OF INCREASED MOISTURE, SEE NOTES
GREATER THAN 20'-0
SEE DETAIL - CONSTRUCTION PROCEDURE (E16)
DOWN STREAM TOE SHAPING TYPICAL (BY FIELD)
TYPICAL SECTION (IF DISTANCE FROM GRADE TO ROCK IS GREATER THAN 20'-0) (BOTTOM ASH & FLY ASH PONDS) 1:30'
CLAY BLANKET AREA (CONTINUOUS WITH CORE)
SUITABLE ROCK
EL 5030
SECT K (H1) 1" = 30'
CLAY BLANKET (IMPERVIOUS)
RANDOM ZONE
RANDOM ROCK SLOPE PROTECTION
EXCAVATED TO SUITABLE ROCK (SEE NOTES)
EXIST GROUND
ANTICIPATED ROCK LEVEL
SECT L (H2) 1" = 30'
NOTES
ROADS SHALL BE CONSTRUCTED OF AGGREGATE BASE TYPE AB-5a AS SPECIFIED IN "STANDARD SPECIFICATIONS FOR ROAD AND BRIDGE CONSTRUCTION OF THE ARIZONA HIGHWAY DEPARTMENT." THE MATERIAL SHALL BE PLACED IN ONE LIFT AND COMPACTED TO 90% MODIFIED PROCTOR DENSITY.
CREST ROADS AND ACCESS ROADS TO BE 15'-0 WIDE WITH 4'-0 SHOULDERS AT BOTH SIDES. CREST ROADS TO BE LOCATED AT THE ℄ OF THE DIKE.
ACCESS ROADS NOT TO HAVE A SLOPE OF MORE THAN 7%.
FOR OTHER NOTES SEE G-556.
SLURRY WALL - IMPERVIOUS ZONE CONTACT TO BE CAREFULLY CONSTRUCTED AS PER DETAIL GIVEN (D13) TYPICAL FOR BOTH FLY ASH AND BOTTOM ASH DAMS.
LOWER TEN FEET OF IMPERVIOUS ZONES FOR BOTH FLY ASH AND BOTTOM ASH DAMS TO BE PLACED AND COMPACTED AT OPTIMUM MOISTURE CONDITIONS AS PER SPECIFICATION APS - 2742-54-09.
THE FOUNDATION FOR THE CLAY BLANKET (H15) SHALL BE EXCAVATED TO SUITABLE ROCK AND CLEANED, MAPPED AND SLUSH GROUTED AS PER SECTION 9 OF SPEC. APS-2742-54-09.
REFERENCE DRAWINGS
FOR REF DWG SEE G-556
SECT A (J2)
SEE DETAIL (D13)
EL 5031
SECT B (J5)
SEE DETAIL (D15)
EL 5012
SECT C (K4)
EL 4998
SECT D (L5)
EL 5016
SECT E (M6)
EL 5063
℄ HWY
SECT F (M7)
SECT G (M8)
EL 5070
EL 5065
SECT H (N9)
20'-0
EL VARIES BY FIELD
1'-0 MIN
RIP RAP BLANKET
SECT M (L4) (N.T.S.)
WORK THIS DWG WITH G-556 & G557
8 | 2-25-77 | ELIMINATED STAGE II CONSTRUCTION AND REVISED SECTIONS, QUANTITIES AND NOTES ACCORDINGLY. ADDED: (E14)(I5) CONSTRUCTION PROCEDURE (H12) SECT. K (H16) SECT. L | T.R. | EW
7 | 9-29-76 | REV: DELETED (F13,C13) SECT & NOTES | RM. | JB
6 | 8-26-76 | REV: (G18) REF DWG (D7,G7) NOTES ADD: (E18) NOTES | J.I. | LC
5 | 7-12-76 | REV: (M12) NOTE ADD: (D13) SECT, (B2) NOTE | J.I. | DC
4 | 5-18-76 | REVISED: (A12) PROFILE (A15,E3,G3,F6,I6) SECT DELETED: B10 THRU E17, PROFILE OF WEIR WALL & TRENCH & SECT K, (A1, C8) WORD | DD | LC
3 | 4-14-76 | GENERAL REVISION | RP | DT
2 | 12-19-75 | REV: (A1,A4,A7,A10) NOTE ADD: (E18) NOTES | J.I. | LC
1 | 9-30-75 | ADD: (A1,A7) NOTE REV: (E3) NOTE (C8) ROCKLINE | J.I. | LC
10 | 11-9-77 | AS BUILT | RM | MT
9 | 5-10-77 | REVISED SHAPE OF D/S TOE (F10), (I10) & SECTS | AC | JE
NO | DATE | REVISION | BY | CH. | APPROVED
ARIZONA PUBLIC SERVICE COMPANY
CHOLLA S.E. STATION
1977 - 250 MW INSTALLATION - UNIT No. 2
1978 - 250 MW EXTENSION - UNIT No. 3
ASH DISPOSAL SYSTEM
FLY ASH POND DIKE - SECTIONS & DETAILS
EBASCO SERVICES INCORPORATED
SCALE 1" = 30'-0 UNLESS NOTED
DIV C-H
DR J. IAFRATE
CH R JONES
APPROVED
DATE AUG. 19, 75
APS-2742
G-558
APS DWG #G-44558
STEPHEN L. CSIBOR

Exhibit 2

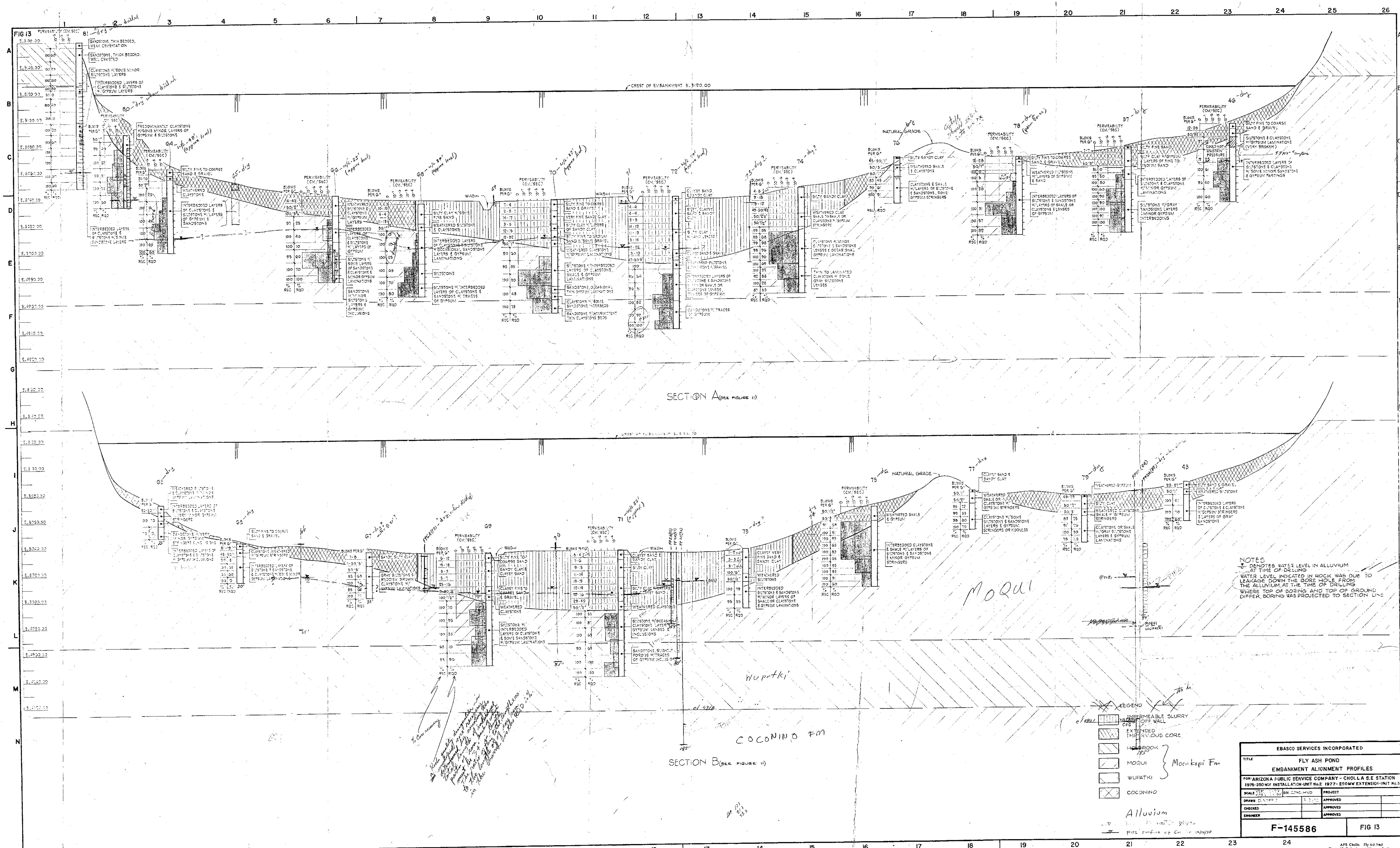


FIG 13
CREST OF EMBANKMENT
NATURAL GRADE
SECTION A (SEE FIGURE 11)
SECTION B (SEE FIGURE 11)
MOQUI
Wupatki
COCONINO FM
NOTES
DENOTES WATER LEVEL IN ALLUVIUM AT TIME OF DRILLING
WATER LEVEL INDICATED IN ROCK WAS DUE TO LEAKAGE DOWN THE BORE HOLE FROM THE ALLUVIUM AT THE TIME OF DRILLING
WHERE TOP OF BORING AND TOP OF GROUND DIFFER, BORING WAS PROJECTED TO SECTION LINE
LEGEND
IMPERMEABLE SLURRY CUT-OFF WALL
EXTENDED IMPERVIOUS CORE
HOLBROOK
MOQUI
WUPATKI
COCONINO
Moenkopi Fm
Alluvium
EBASCO SERVICES INCORPORATED
FLY ASH POND
EMBANKMENT ALIGNMENT PROFILES
FOR ARIZONA PUBLIC SERVICE COMPANY - CHOLLA S.E. STATION
F-145586
FIG 13

Exhibit 3

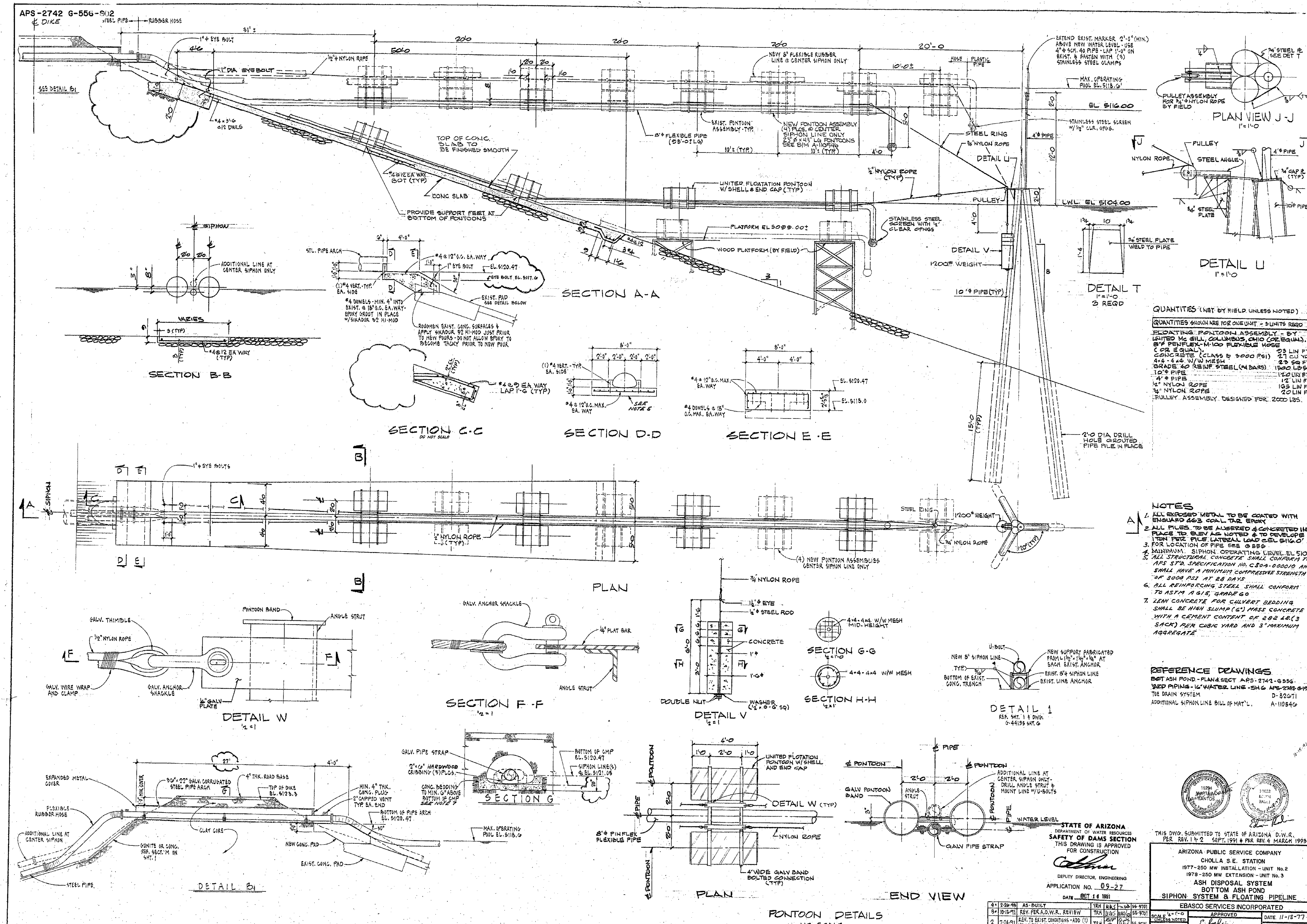


Exhibit 4

#G-44556 sht2

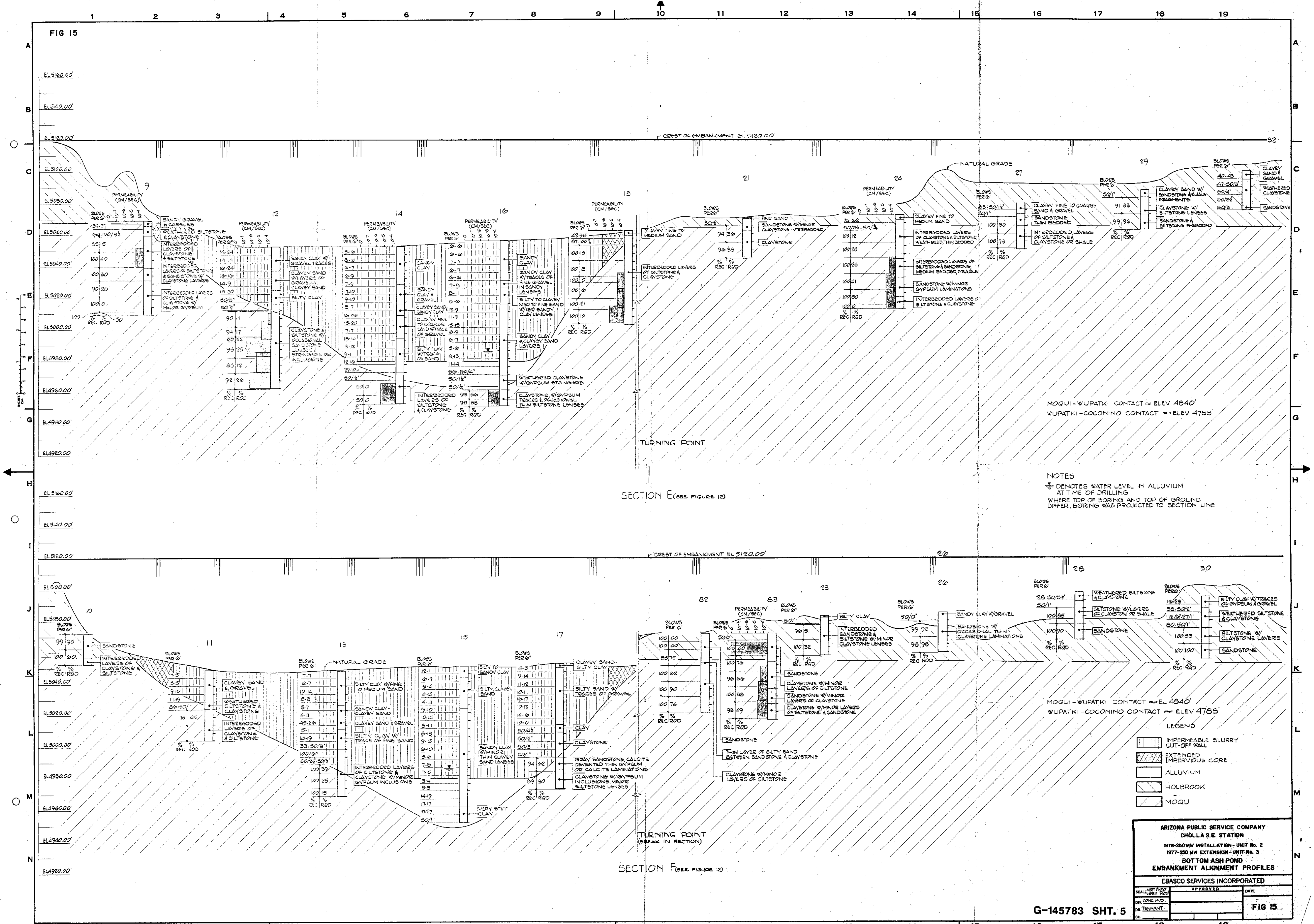


FIG 15
CREST OF EMBANKMENT EL 5120.00'
NATURAL GRADE
TURNING POINT
SECTION E (SEE FIGURE 12)
MOQUI-WUPATKI CONTACT ≈ ELEV 4840'
WUPATKI-COCONINO CONTACT ≈ ELEV 4788'
NOTES
DENOTES WATER LEVEL IN ALLUVIUM AT TIME OF DRILLING
WHERE TOP OF BORING AND TOP OF GROUND DIFFER, BORING WAS PROJECTED TO SECTION LINE
TURNING POINT (BREAK IN SECTION)
SECTION F (SEE FIGURE 12)
LEGEND
IMPERMEABLE SLURRY CUT-OFF WALL
EXTENDED IMPERVIOUS CORE
ALLUVIUM
HOLBROOK
MOQUI
ARIZONA PUBLIC SERVICE COMPANY
CHOLLA S.E. STATION
1976-250 MW INSTALLATION - UNIT No. 2
1977-250 MW EXTENSION - UNIT No. 3
BOTTOM ASH POND
EMBANKMENT ALIGNMENT PROFILES
EBASCO SERVICES INCORPORATED
G-145783 SHT. 5
FIG 15

Exhibit 5

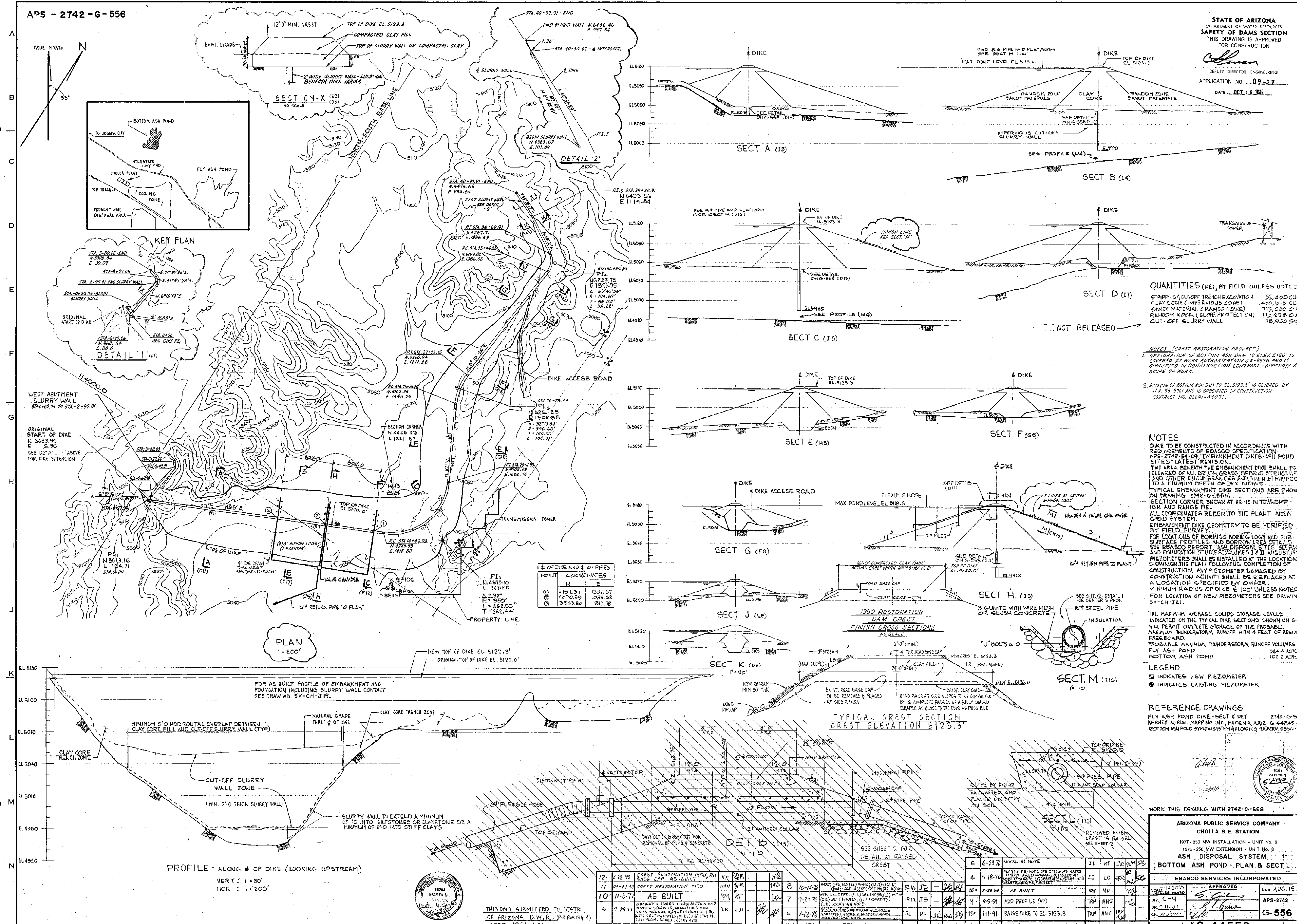
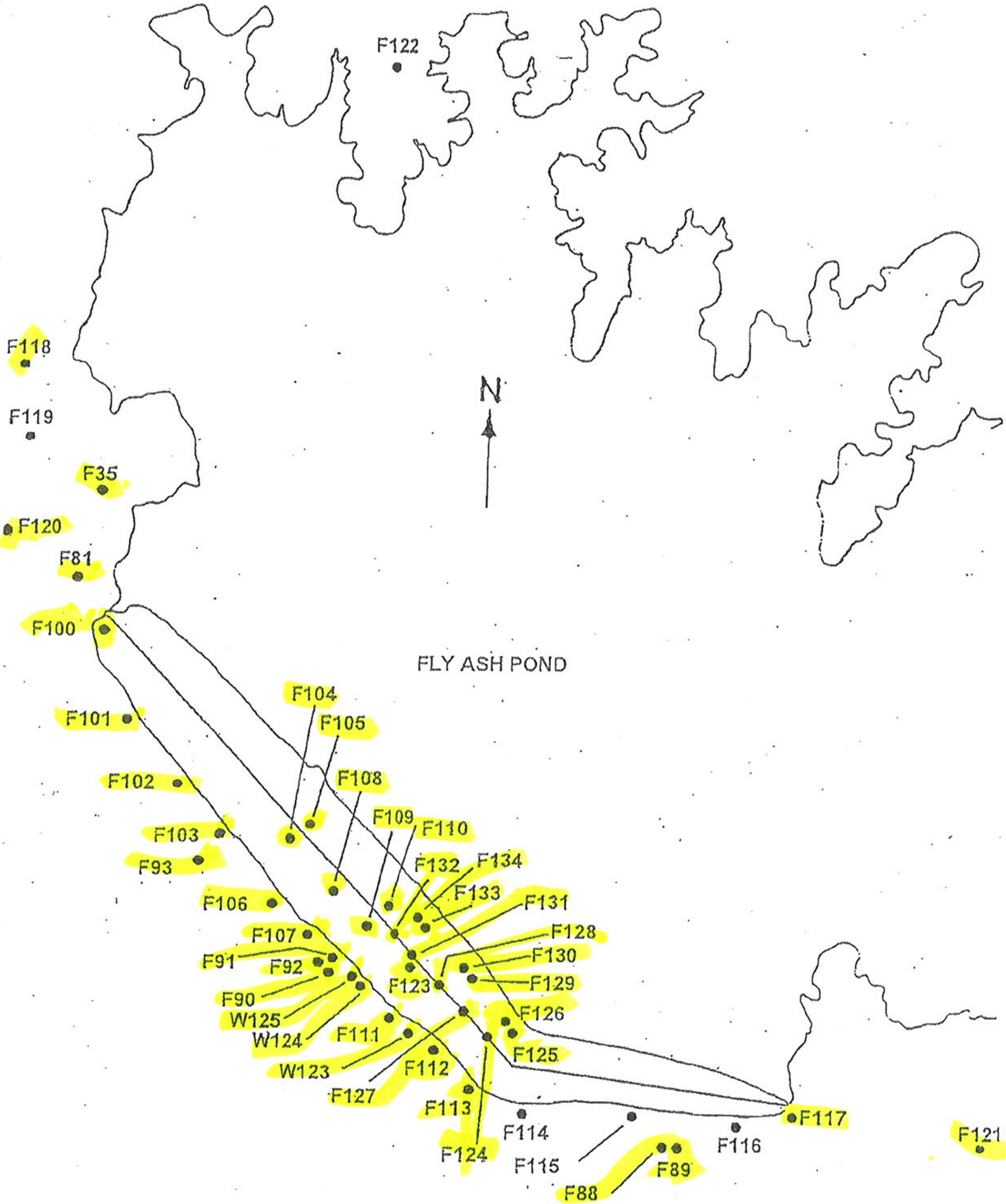

APS - 2742-G-556
STATE OF ARIZONA
DEPARTMENT OF WATER RESOURCES
SAFETY OF DAMS SECTION
THIS DRAWING IS APPROVED
FOR CONSTRUCTION
DEPUTY DIRECTOR, ENGINEERING
APPLICATION NO. 09-37
TRUE NORTH
SECTION-X
NO SCALE
DETAIL '2'
KEY PLAN
DETAIL '1'
SECT A
SECT B
SECT C
SECT D
SECT E
SECT F
SECT G
SECT H
SECT J
SECT K
SECT. M
SECT. L
DIKE ACCESS ROAD
TRANSMISSION TOWER
PROPERTY LINE
10" RETURN PIPE TO PLANT
NOT RELEASED
PLAN
1" = 200'
QUANTITIES (NET, BY FIELD UNLESS NOTED)
STRIPPING & CUT-OFF TRENCH EXCAVATION 55,400 CU YD
CLAY CORE (IMPERVIOUS ZONE) 430,515 CU YD
SANDY MATERIAL (RANDOM ZONE) 775,000 CU YD
RANDOM ROCK (SLOPE PROTECTION) 113,228 CU YD
CUT-OFF SLURRY WALL 78,900 SQ FT
NOTES: (CREST RESTORATION PROJECT)
1. RESTORATION OF BOTTOM ASH DAM TO ELEV 5120' IS COVERED BY WORK AUTHORIZATION 54-9976 AND IS SPECIFIED IN CONSTRUCTION CONTRACT - APPENDIX A, SCOPE OF WORK.
2. RAISING OF BOTTOM ASH DAM TO EL. 5123.3' IS COVERED BY W.A. 55-3701 AND IS SPECIFIED IN CONSTRUCTION CONTRACT NO. ELC91-43071.
NOTES
DIKE TO BE CONSTRUCTED IN ACCORDANCE WITH REQUIREMENTS OF EBASCO SPECIFICATION APS-2742-54-09, "EMBANKMENT DIKES-ASH POND SITES" LATEST REVISION.
THE AREA BENEATH THE EMBANKMENT DIKE SHALL BE CLEARED OF ALL BRUSH, GRASS, DEBRIS, STRUCTURES AND OTHER ENCUMBRANCES AND THEN STRIPPED TO A MINIMUM DEPTH OF SIX INCHES.
TYPICAL EMBANKMENT DIKE SECTIONS ARE SHOWN ON DRAWING 2742-G-558.
SECTION CORNER SHOWN AT H6 IS IN TOWNSHIP 18N AND RANGE 19E.
ALL COORDINATES REFER TO THE PLANT AREA GRID SYSTEM.
EMBANKMENT DIKE GEOMETRY TO BE VERIFIED BY FIELD SURVEY.
FOR LOCATIONS OF BORINGS, BORING LOGS AND SUBSURFACE PROFILES AND BORROW AREA DETAILS SEE EBASCO REPORT "ASH DISPOSAL SITES - SEEPAGE AND FOUNDATION STUDIES" VOLUMES I & II AUGUST, 1975.
PIEZOMETERS SHALL BE INSTALLED AT THE LOCATIONS SHOWN ON THE PLAN FOLLOWING COMPLETION OF CONSTRUCTION. ANY PIEZOMETER DAMAGED BY CONSTRUCTION ACTIVITY SHALL BE REPLACED AT A LOCATION SPECIFIED BY OWNER.
MINIMUM RADIUS OF DIKE ℄ 100' UNLESS NOTED.
FOR LOCATION OF NEW PIEZOMETERS SEE DRAWING SK-CH-J21.
THE MAXIMUM AVERAGE SOLIDS STORAGE LEVELS INDICATED ON THE TYPICAL DIKE SECTIONS SHOWN ON G-558 WILL PERMIT COMPLETE STORAGE OF THE PROBABLE MAXIMUM THUNDERSTORM RUNOFF WITH 4 FEET OF RESIDUAL FREEBOARD.
PROBABLE MAXIMUM THUNDERSTORM RUNOFF VOLUMES ARE:
FLY ASH POND 964.4 ACRE-FT
BOTTOM ASH POND 107.7 ACRE-FT
LEGEND
INDICATES NEW PIEZOMETER
INDICATES EXISTING PIEZOMETER
REFERENCE DRAWINGS
FLY ASH POND DIKE - SECT & DET 2742-G-558
KENNEY AERIAL MAPPING INC., PHOENIX ARIZ G-44249-SN1
BOTTOM ASH POND SYPHON SYSTEM & FLOATING PLATFORM G-556-S02
WORK THIS DRAWING WITH 2742-G-558
1990 RESTORATION
DAM CREST
FINISH CROSS SECTIONS
NO SCALE
TYPICAL CREST SECTION
CREST ELEVATION 5123.3'
DET B
PROFILE - ALONG ℄ OF DIKE (LOOKING UPSTREAM)
VERT: 1" = 30'
HOR: 1" = 200'
FOR AS BUILT PROFILE OF EMBANKMENT AND FOUNDATION INCLUDING SLURRY WALL CONTACT SEE DRAWING SK-CH-J19.
NEW TOP OF DIKE EL. 5123.3'
ORIGINAL TOP OF DIKE EL. 5120.0'
CLAY CORE TRENCH ZONE
CUT-OFF SLURRY WALL ZONE
(MIN. 2'-0 THICK SLURRY WALL)
SLURRY WALL TO EXTEND A MINIMUM OF 10' INTO SILTSTONES OR CLAYSTONE OR A MINIMUM OF 2'-0 INTO STIFF CLAYS
THIS DWG. SUBMITTED TO STATE OF ARIZONA D.W.R. (PER REV. 13 & 14) SEPT. 1991 & PER REV. 15 MAR. 1993
ARIZONA PUBLIC SERVICE COMPANY
CHOLLA S.E. STATION
1977 - 250 MW INSTALLATION - UNIT No. 2
1978 - 250 MW EXTENSION - UNIT No. 3
ASH DISPOSAL SYSTEM
BOTTOM ASH POND - PLAN & SECT
EBASCO SERVICES INCORPORATED
DATE AUG. 19, '75
APS-2742
G-556
APS DWG. #G-44556
15 2-25-93 AS BUILT
14 4-9-91 ADD PROFILE (N7)
13 7-11-91 RAISE DIKE TO EL. 5123.3
10 11-8-77 AS BUILT
8 10-14-76
7 9-29-76
6 7-12-76
5 6-29-76
4 5-18-76

Exhibit 6

Appendix A

Instrumentation



CHOLLA FLY ASH POND
PIEZOMETER LOCATION PLAN

FIGURE 1

CHOLLA FLY ASH POND

Abutment Piezometers - Moqui Member of the Moenkopi Formation

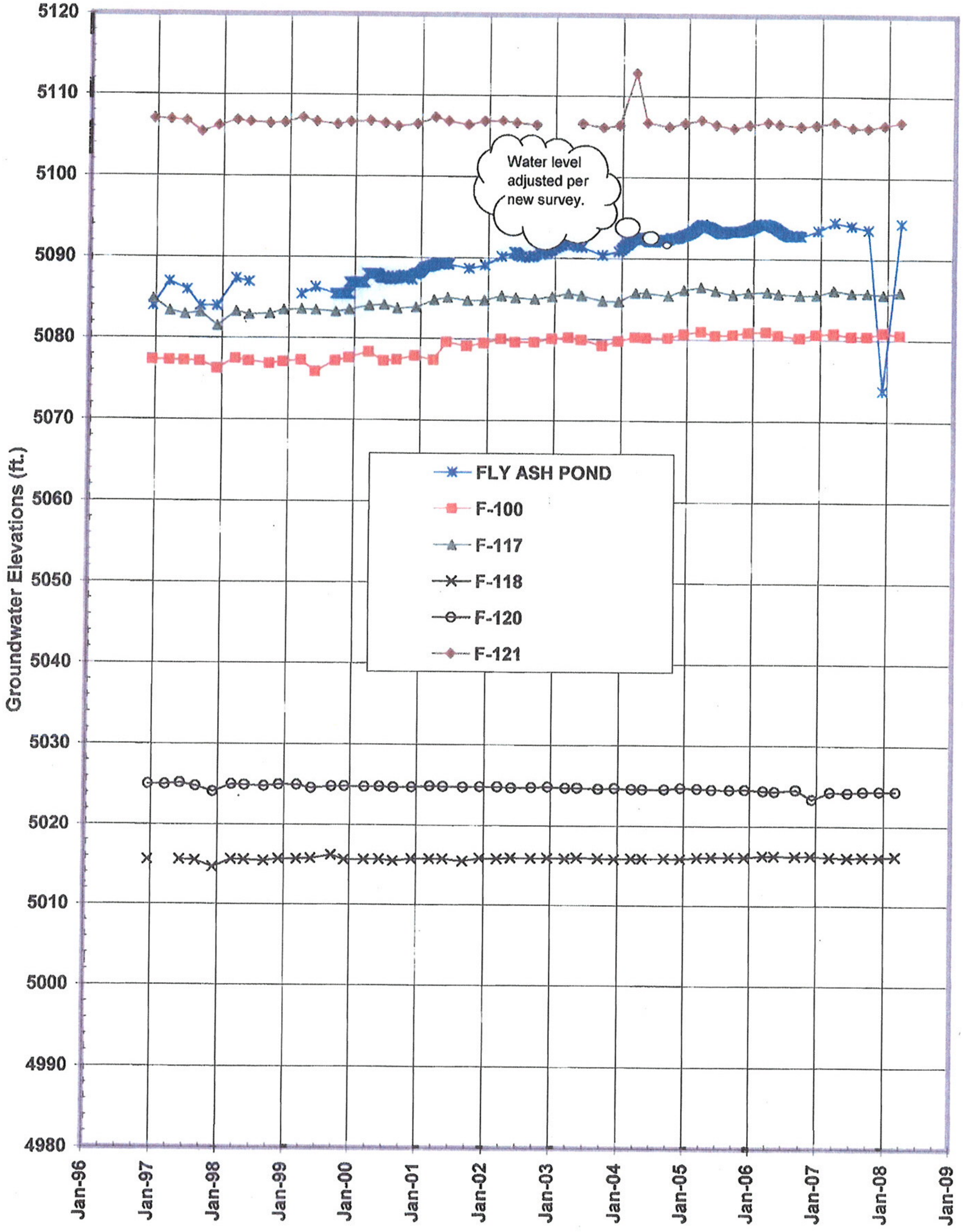
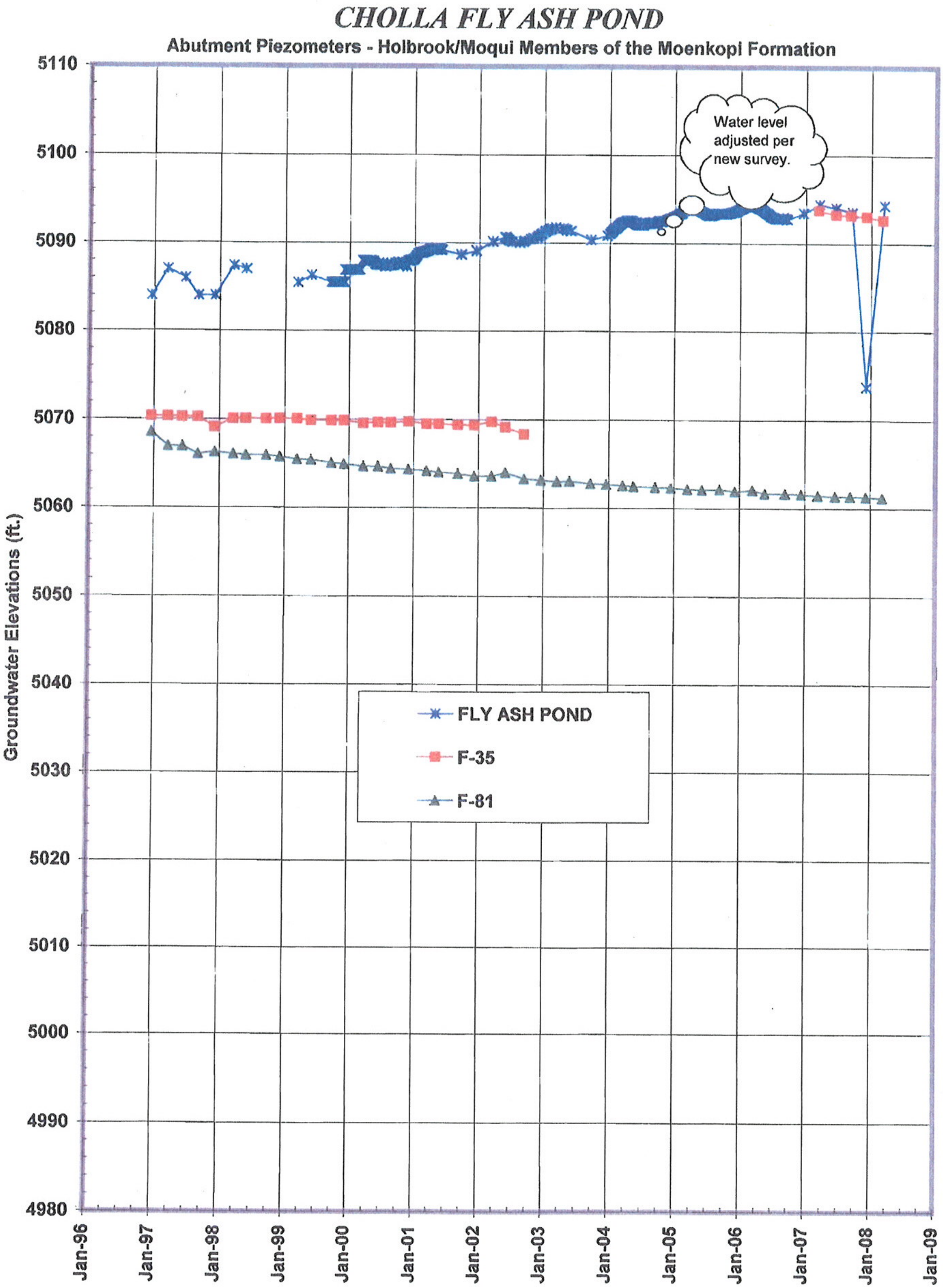


FIGURE 2



CHOLLA FLY ASH POND
Abutment Piezometers - Holbrook/Moqui Members of the Moenkopi Formation
Groundwater Elevations (ft.)
5110
5100
5090
5080
5070
5060
5050
5040
5030
5020
5010
5000
4990
4980
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Water level adjusted per new survey.
FLY ASH POND
F-35
F-81

FIGURE 3

CHOLLA FLY ASH POND

Embankment Piezometers - Alluvium

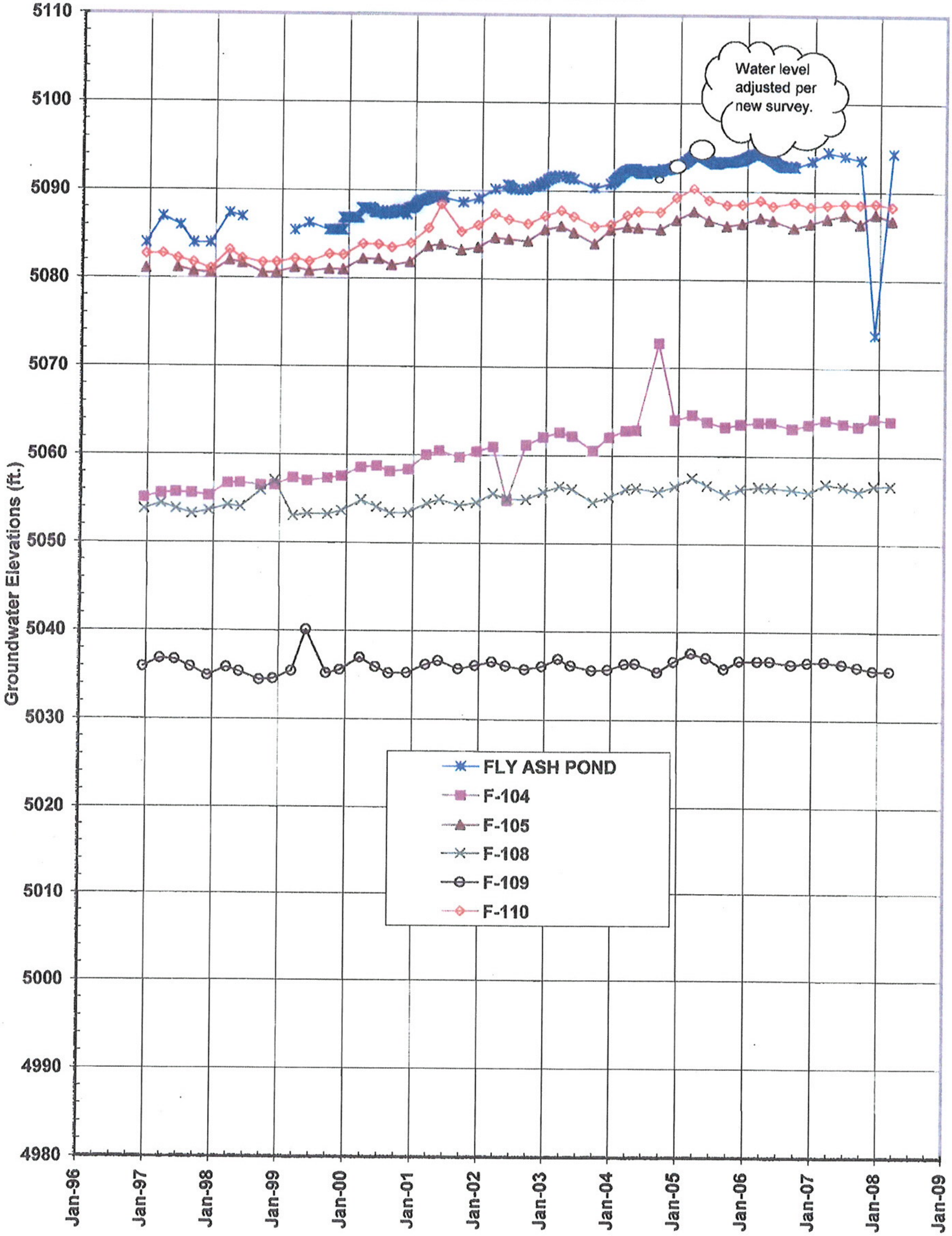


FIGURE 4

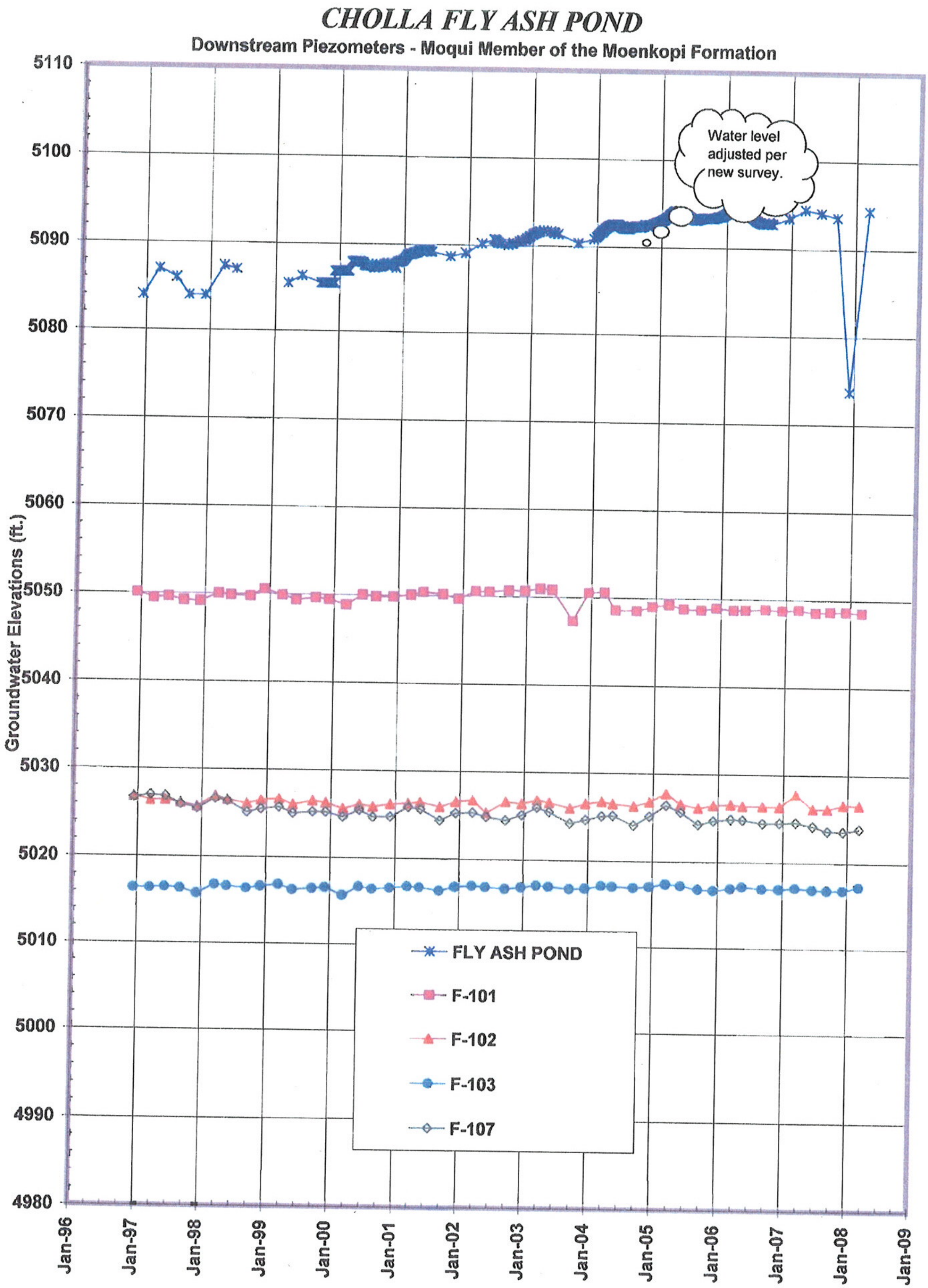

CHOLLA FLY ASH POND
Downstream Piezometers - Moqui Member of the Moenkopi Formation
Water level adjusted per new survey.
Groundwater Elevations (ft.)
5110
5100
5090
5080
5070
5060
5050
5040
5030
5020
5010
5000
4990
4980
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
FLY ASH POND
F-101
F-102
F-103
F-107

FIGURE 5

CHOLLA FLY ASH POND

Downstream Piezometers - Moqui Member of the Moenkopi Formation

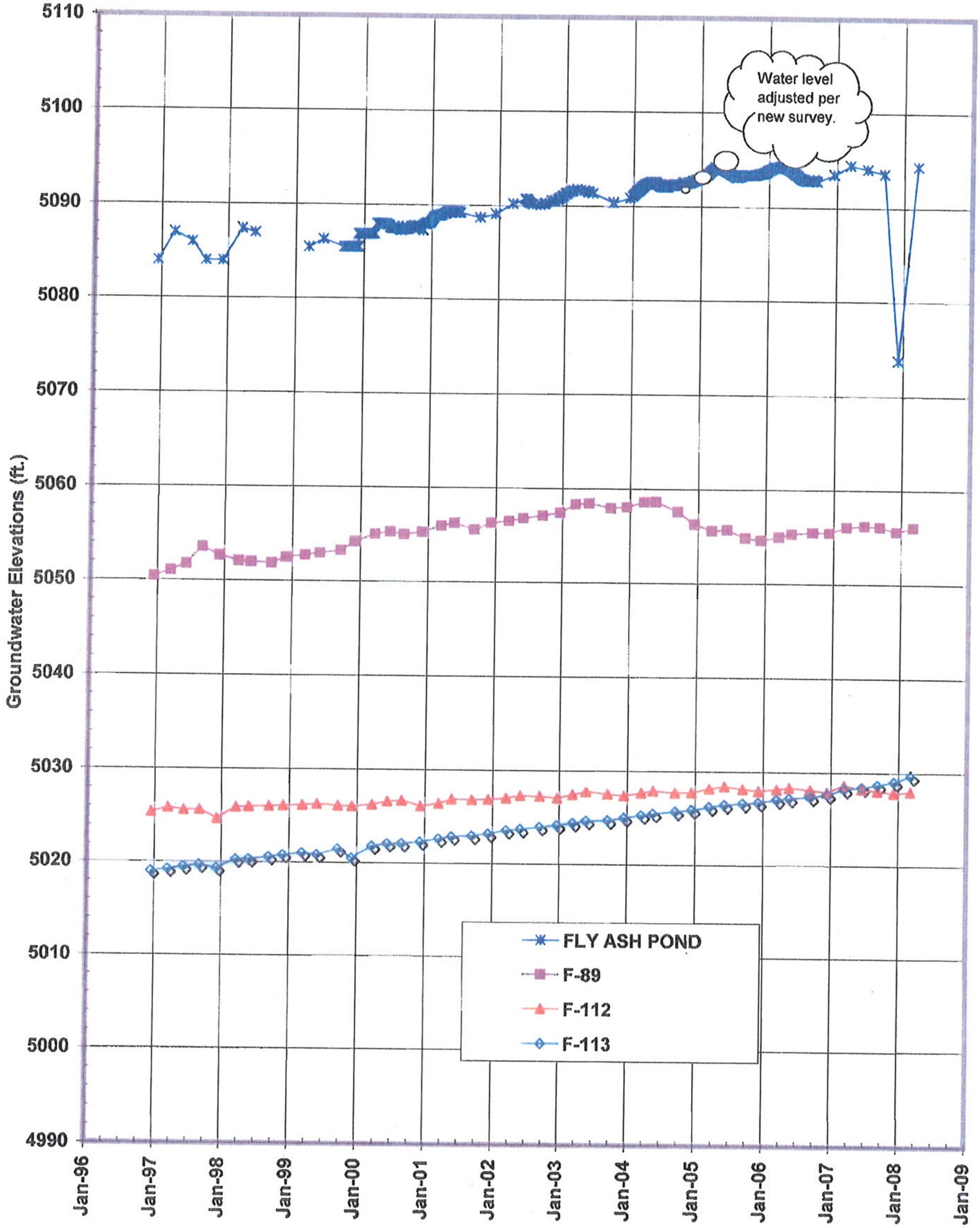
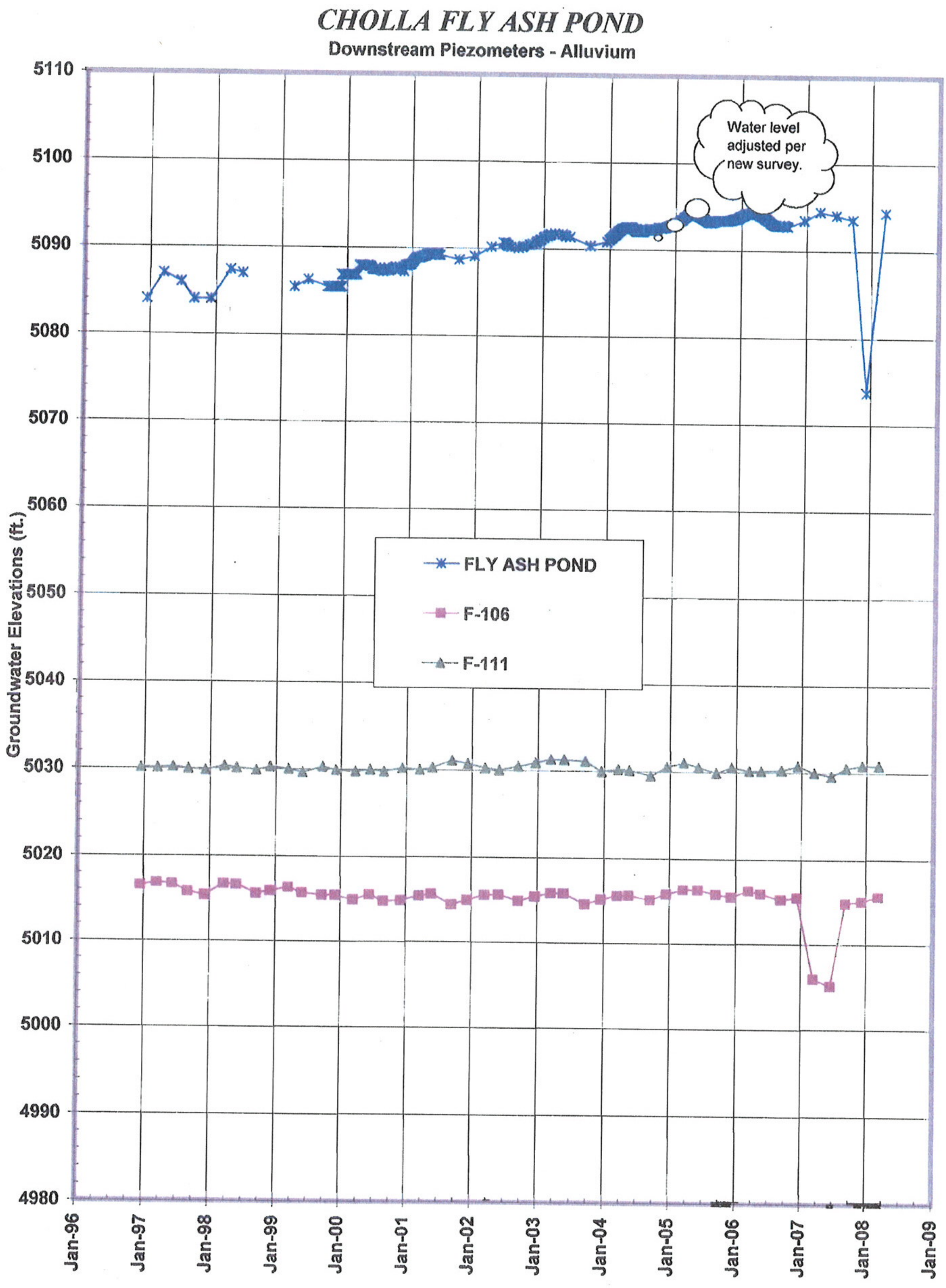


FIGURE 6



CHOLLA FLY ASH POND
Downstream Piezometers - Alluvium
Groundwater Elevations (ft.)
5110
5100
5090
5080
5070
5060
5050
5040
5030
5020
5010
5000
4990
4980
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Water level adjusted per new survey.
FLY ASH POND
F-106
F-111

FIGURE 7

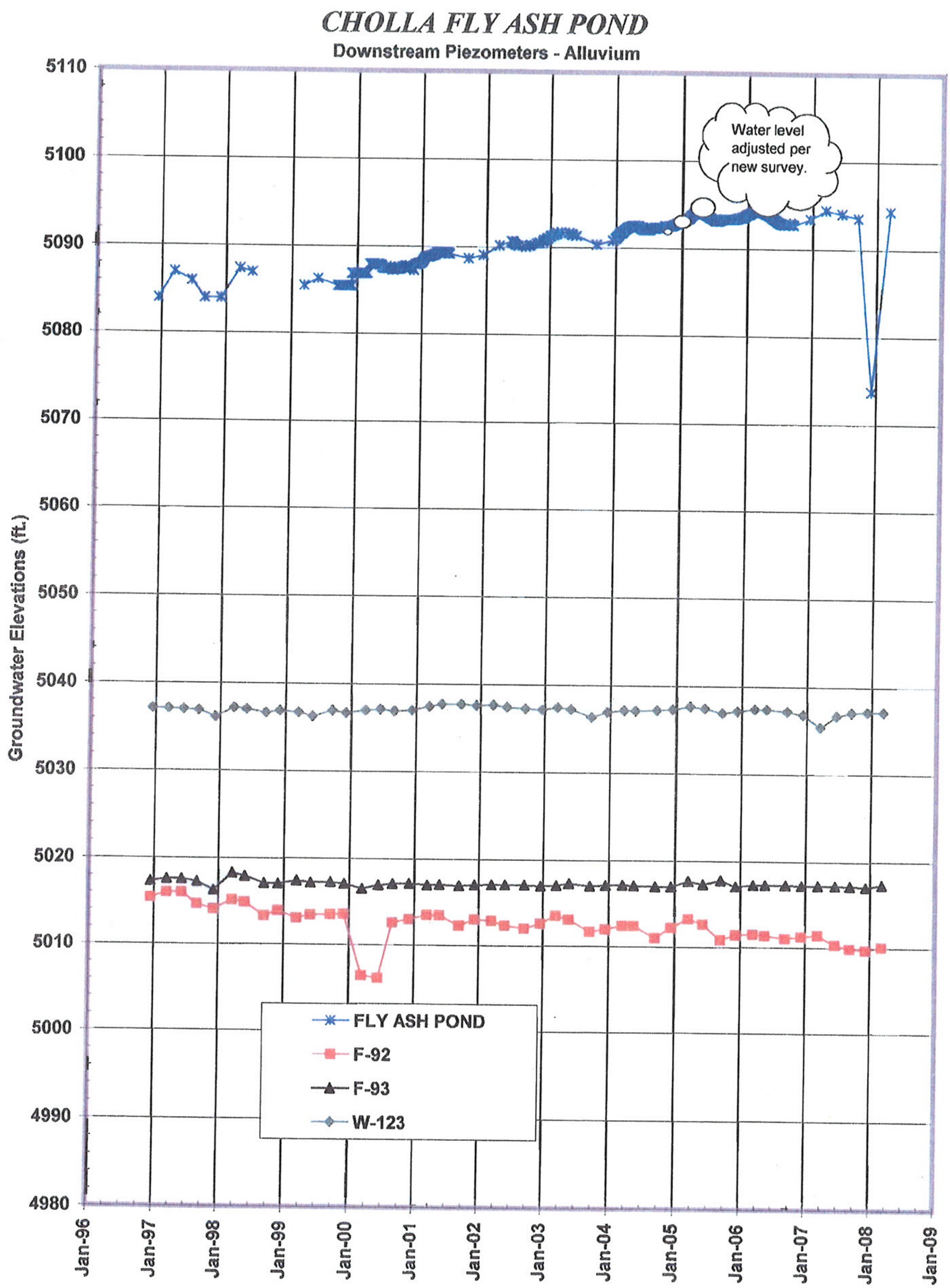
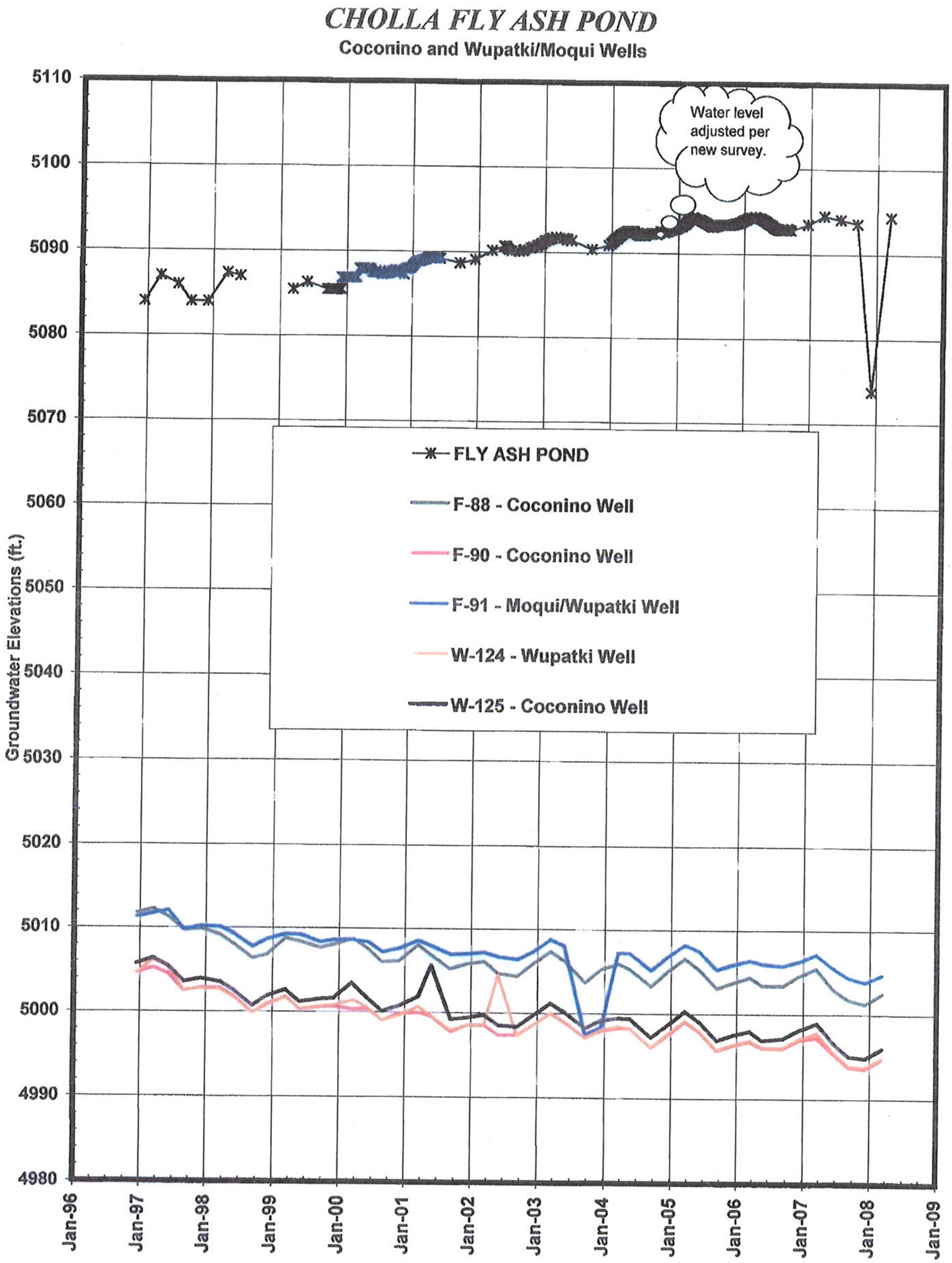

CHOLLA FLY ASH POND
Downstream Piezometers - Alluvium
Groundwater Elevations (ft.)
5110
5100
5090
5080
5070
5060
5050
5040
5030
5020
5010
5000
4990
4980
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Water level adjusted per new survey.
FLY ASH POND
F-92
F-93
W-123

FIGURE 8



CHOLLA FLY ASH POND
Coconino and Wupatki/Moqui Wells
Water level adjusted per new survey.
FLY ASH POND
F-88 - Coconino Well
F-90 - Coconino Well
F-91 - Moqui/Wupatki Well
W-124 - Wupatki Well
W-125 - Coconino Well
Groundwater Elevations (ft.)
5110
5100
5090
5080
5070
5060
5050
5040
5030
5020
5010
5000
4990
4980
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09

FIGURE 9

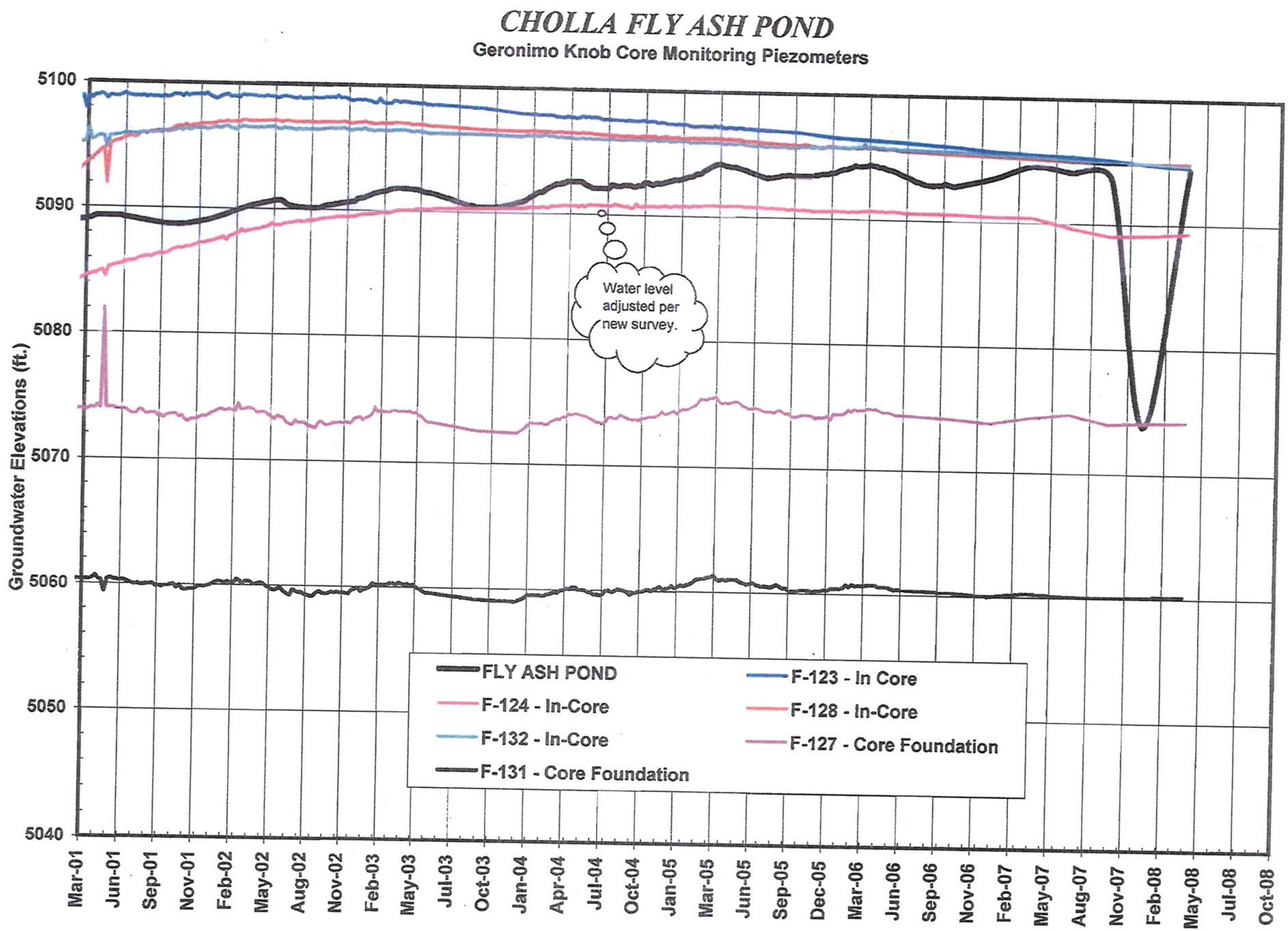

CHOLLA FLY ASH POND
Geronimo Knob Core Monitoring Piezometers
Groundwater Elevations (ft.)
5100
5090
5080
5070
5060
5050
5040
Water level adjusted per new survey.
FLY ASH POND
F-123 - In Core
F-124 - In-Core
F-128 - In-Core
F-132 - In-Core
F-127 - Core Foundation
F-131 - Core Foundation
Mar-01
Jun-01
Sep-01
Nov-01
Feb-02
May-02
Aug-02
Nov-02
Feb-03
May-03
Jul-03
Oct-03
Jan-04
Apr-04
Jul-04
Oct-04
Jan-05
Mar-05
Jun-05
Sep-05
Dec-05
Mar-06
Jun-06
Sep-06
Nov-06
Feb-07
May-07
Aug-07
Nov-07
Feb-08
May-08
Jul-08
Oct-08

FIGURE 16C

CHOLLA FLY ASH POND

Geronimo Knob Shell Monitoring Piezometers

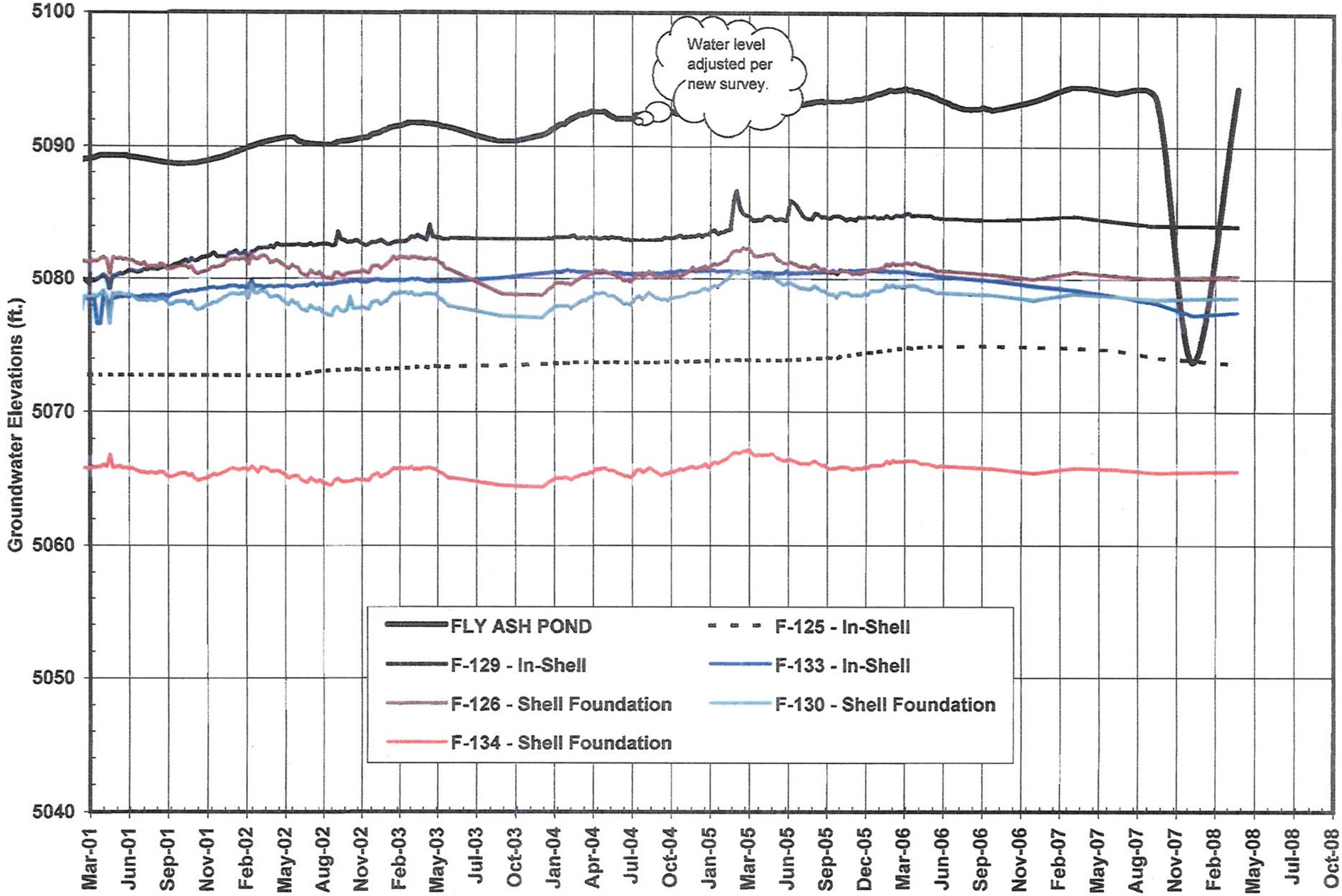
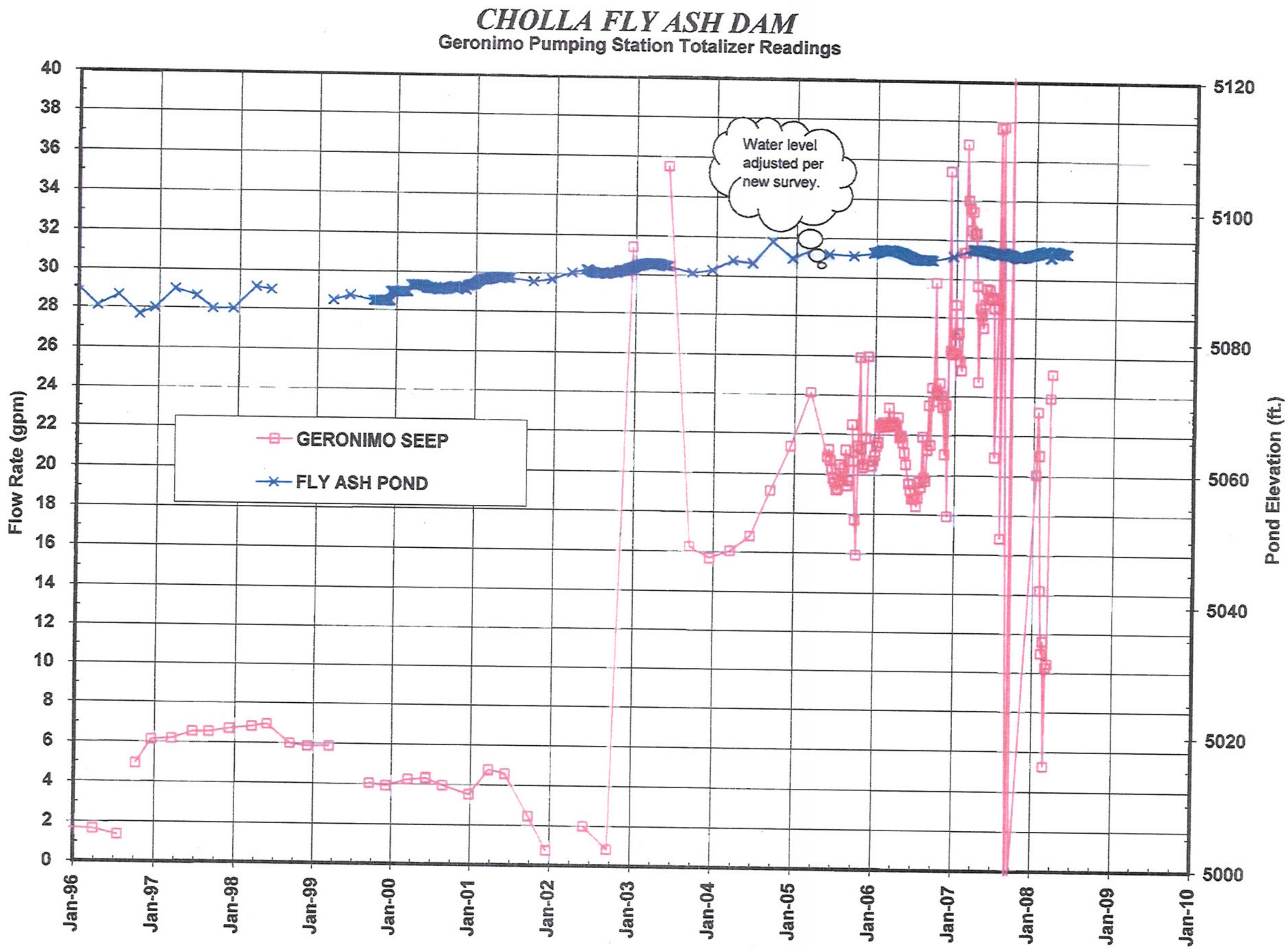


FIGURE 16 D

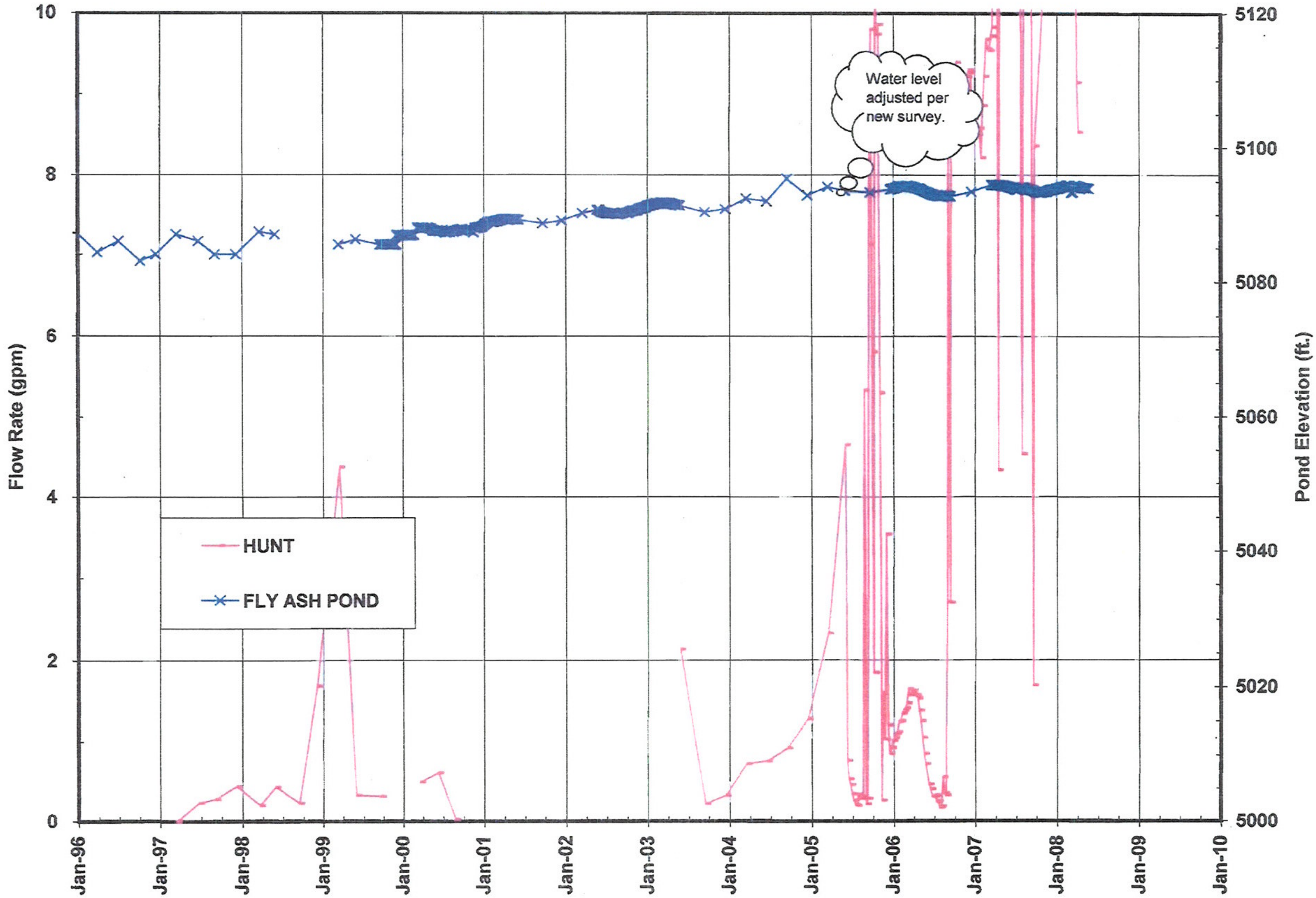


CHOLLA FLY ASH DAM
Geronimo Pumping Station Totalizer Readings
Water level adjusted per new survey.
GERONIMO SEEP
FLY ASH POND
Flow Rate (gpm)
Pond Elevation (ft.)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
5000
5020
5040
5060
5080
5100
5120
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10

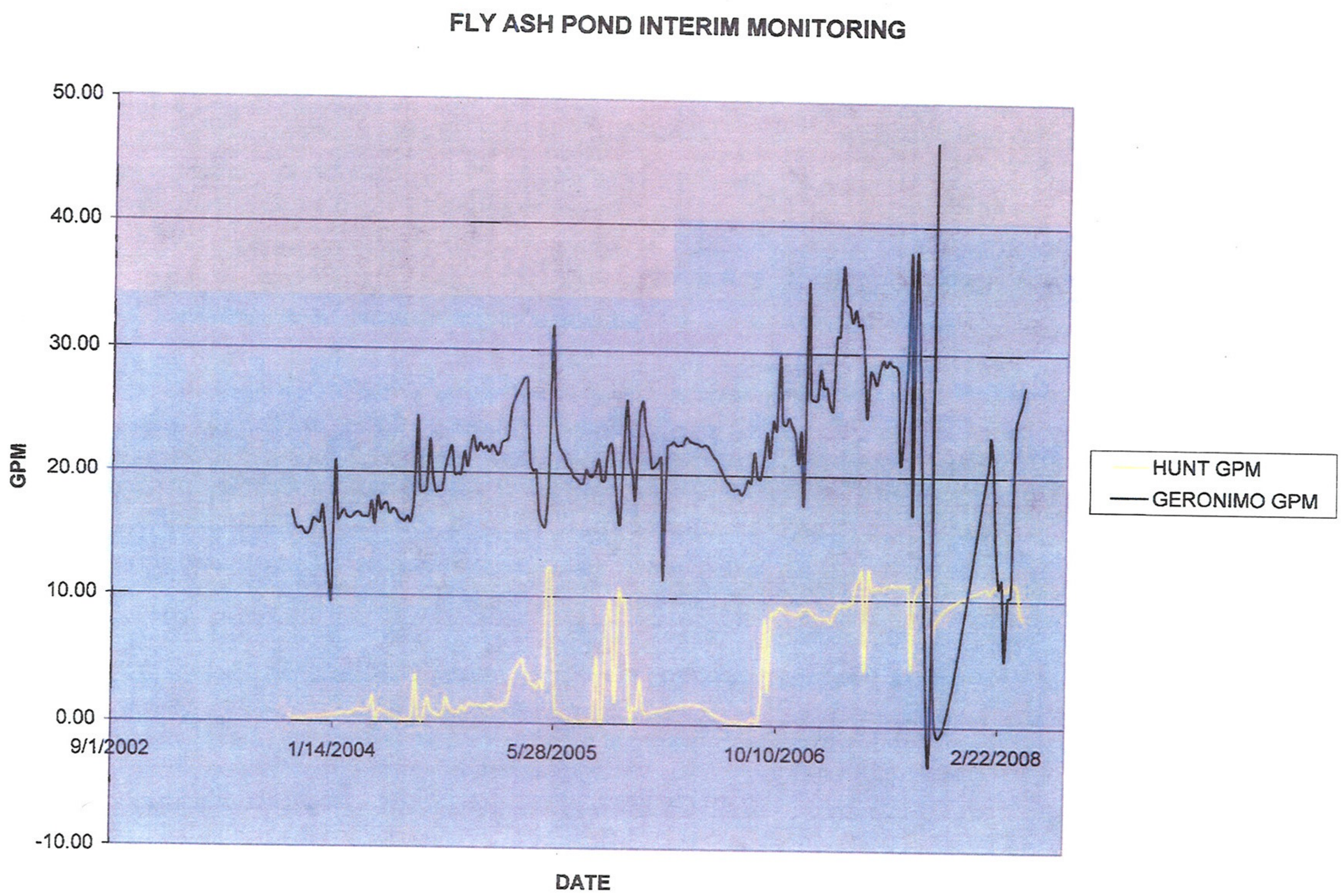
GRAPH 11A

CHOLLA FLY ASH DAM

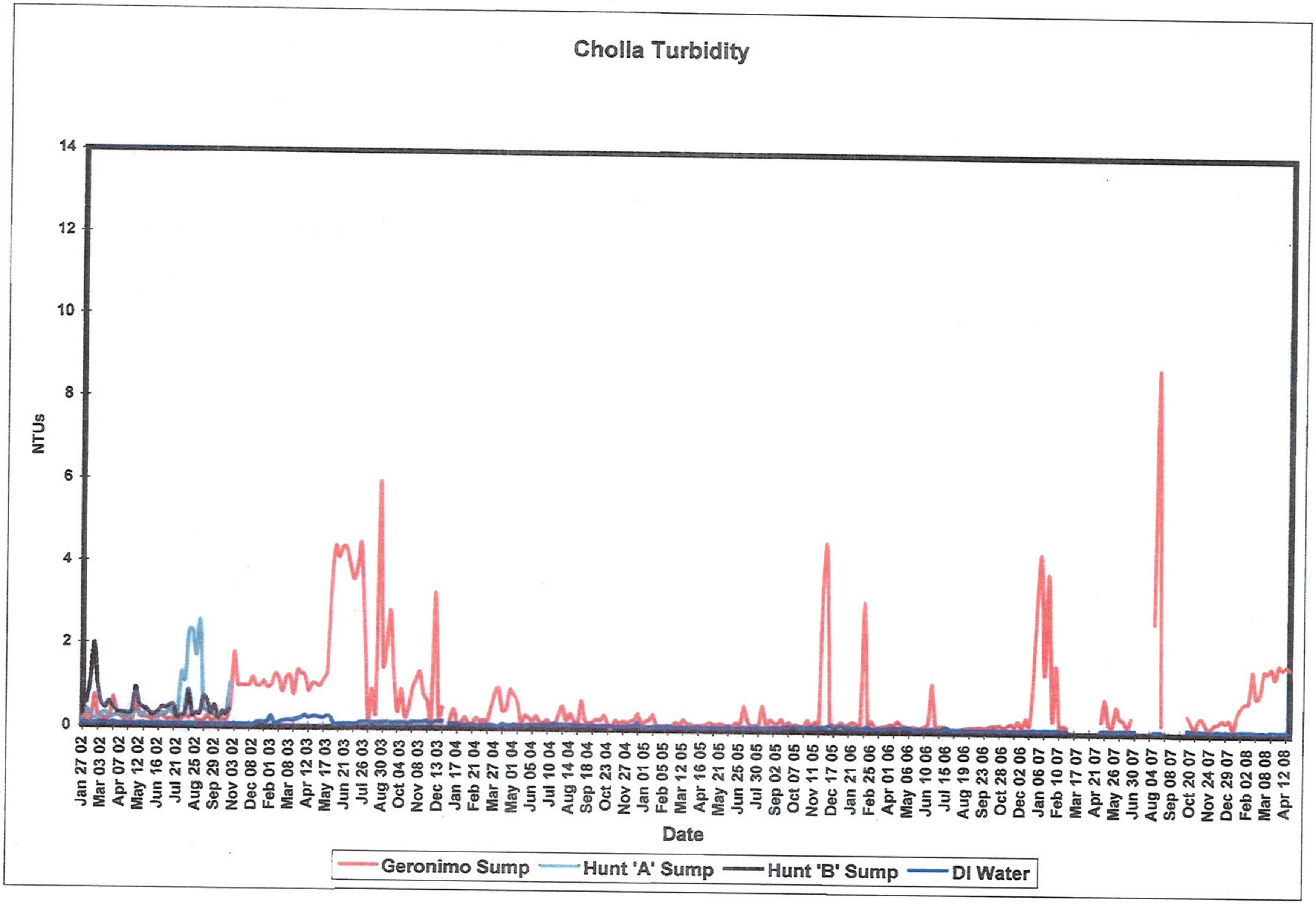
Hunt Pumping Station Totalizer Readings



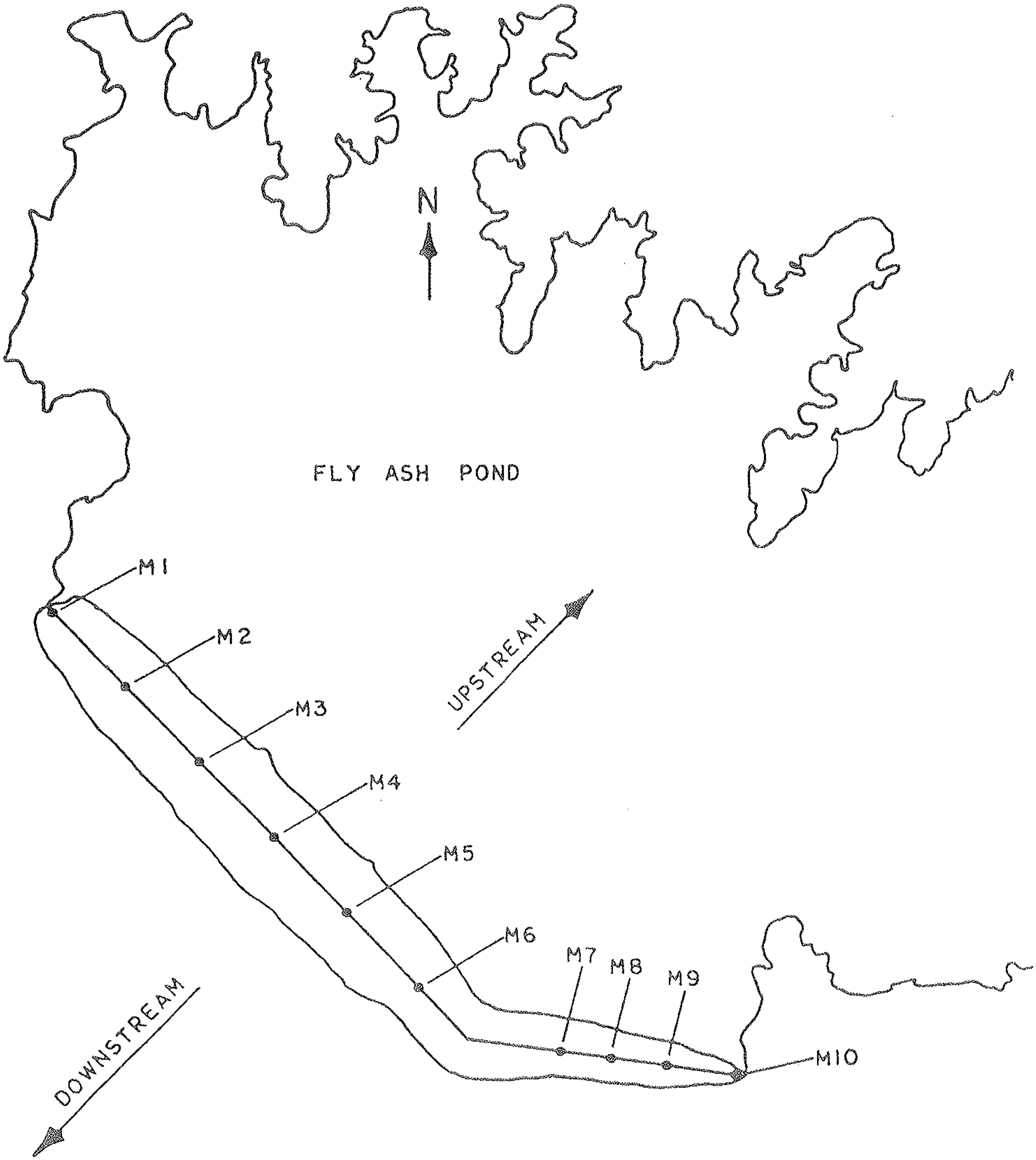
GRAPH 11B



FLY ASH POND INTERIM MONITORING
GPM
50.00
40.00
30.00
20.00
10.00
0.00
-10.00
9/1/2002
1/14/2004
5/28/2005
10/10/2006
2/22/2008
DATE
HUNT GPM
GERONIMO GPM



Cholla Turbidity
NTUs
14
12
10
8
6
4
2
0
Jan 27 02
Mar 03 02
Apr 07 02
May 12 02
Jun 16 02
Jul 21 02
Aug 25 02
Sep 29 02
Nov 03 02
Dec 08 02
Feb 01 03
Mar 08 03
Apr 12 03
May 17 03
Jun 21 03
Jul 26 03
Aug 30 03
Oct 04 03
Nov 08 03
Dec 13 03
Jan 17 04
Feb 21 04
Mar 27 04
May 01 04
Jun 05 04
Jul 10 04
Aug 14 04
Sep 18 04
Oct 23 04
Nov 27 04
Jan 01 05
Feb 05 05
Mar 12 05
Apr 16 05
May 21 05
Jun 25 05
Jul 30 05
Sep 02 05
Oct 07 05
Nov 11 05
Dec 17 05
Jan 21 06
Feb 25 06
Apr 01 06
May 06 06
Jun 10 06
Jul 15 06
Aug 19 06
Sep 23 06
Oct 28 06
Dec 02 06
Jan 06 07
Feb 10 07
Mar 17 07
Apr 21 07
May 26 07
Jun 30 07
Aug 04 07
Sep 08 07
Oct 20 07
Nov 24 07
Dec 29 07
Feb 02 08
Mar 08 08
Apr 12 08
Date
Geronimo Sump
Hunt 'A' Sump
Hunt 'B' Sump
DI Water



CHOLLA FLY ASH POND

MONUMENT LOCATION PLAN

FIGURE 12

CH079624

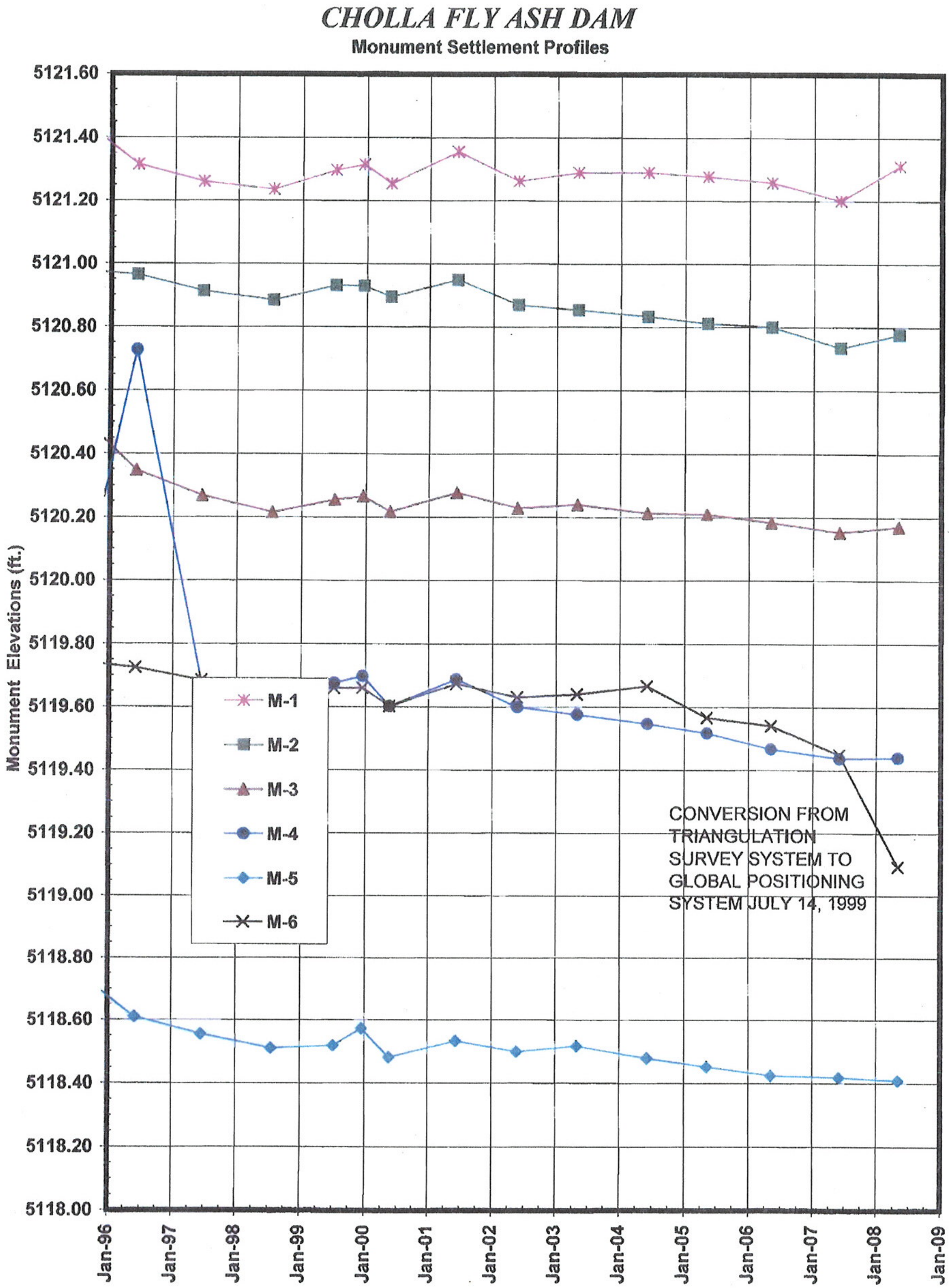

CHOLLA FLY ASH DAM
Monument Settlement Profiles
Monument Elevations (ft.)
5121.60
5121.40
5121.20
5121.00
5120.80
5120.60
5120.40
5120.20
5120.00
5119.80
5119.60
5119.40
5119.20
5119.00
5118.80
5118.60
5118.40
5118.20
5118.00
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
M-1
M-2
M-3
M-4
M-5
M-6
CONVERSION FROM TRIANGULATION SURVEY SYSTEM TO GLOBAL POSITIONING SYSTEM JULY 14, 1999

FIGURE 13

CHOLLA FLY ASH DAM

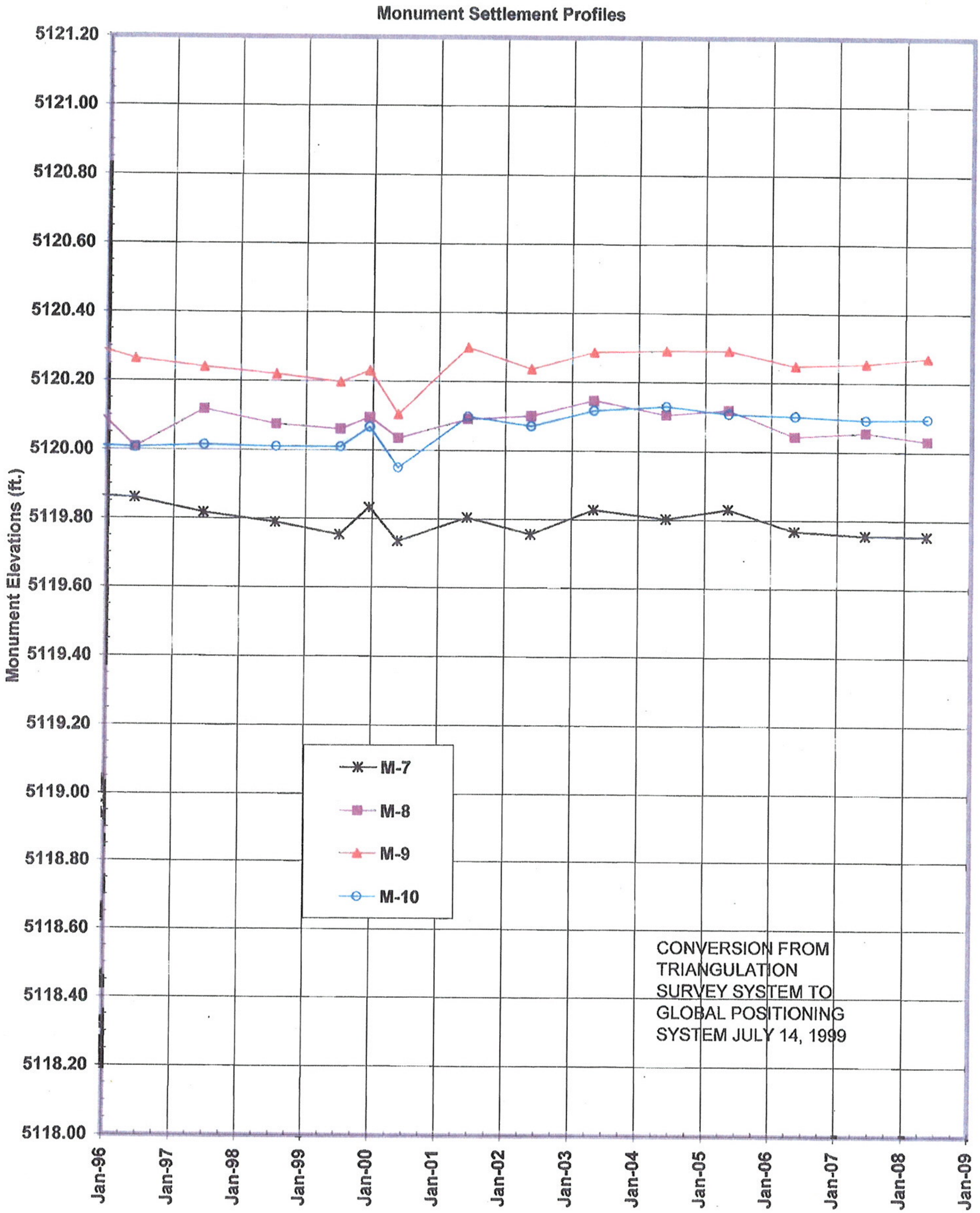


FIGURE 14

CHOLLA FLY ASH DAM

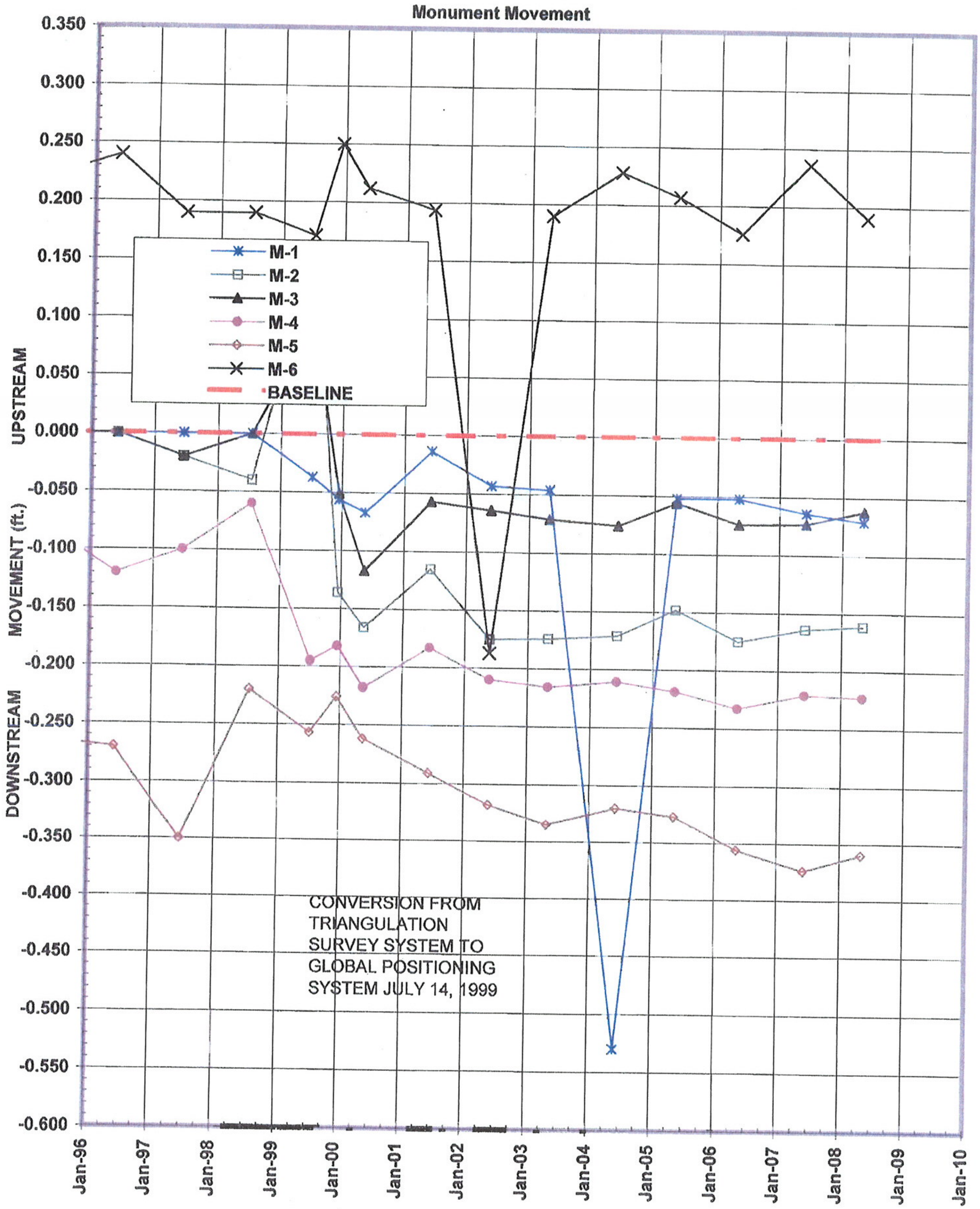


FIGURE 15

CHOLLA FLY ASH DAM

Monument Movement

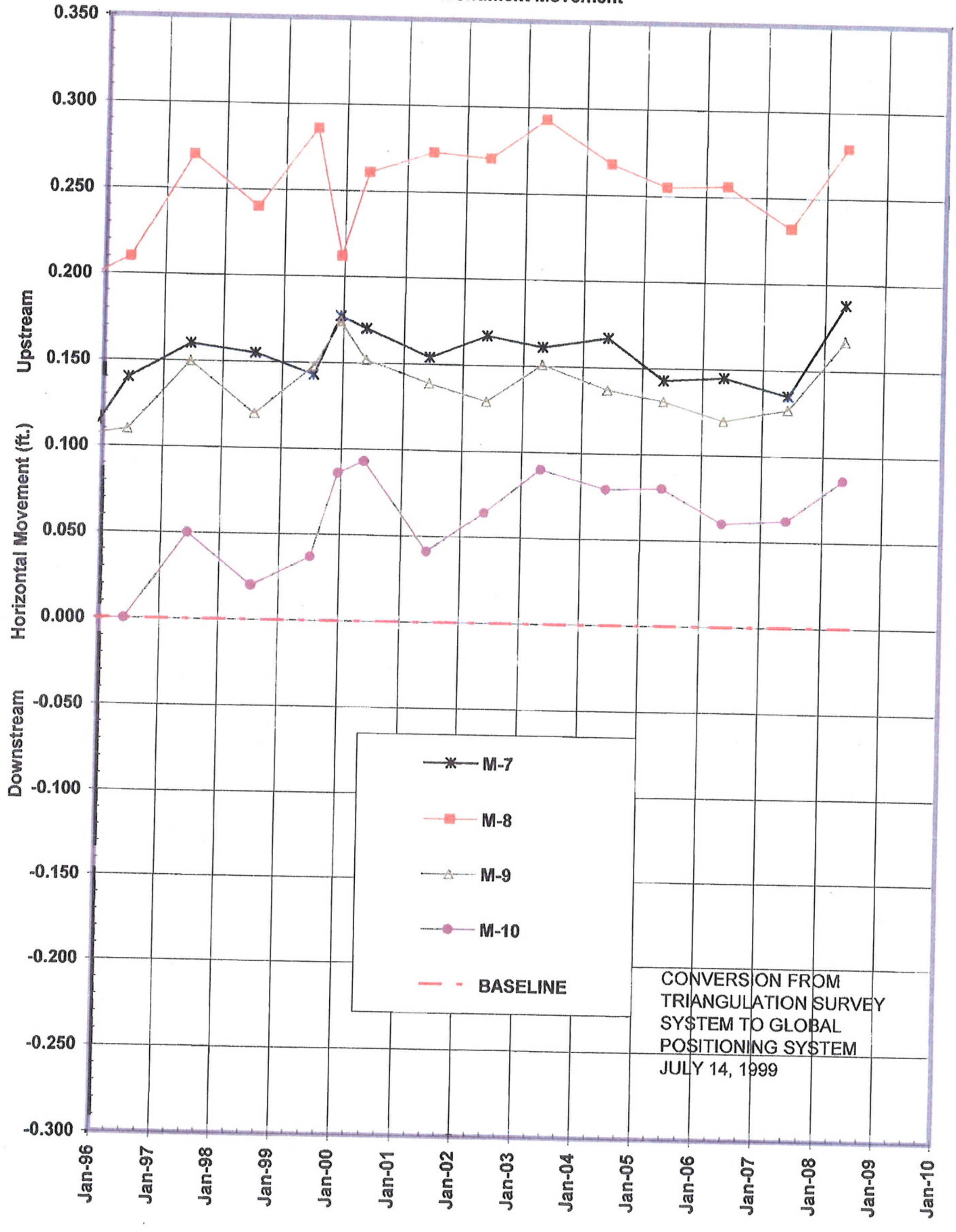


FIGURE 16

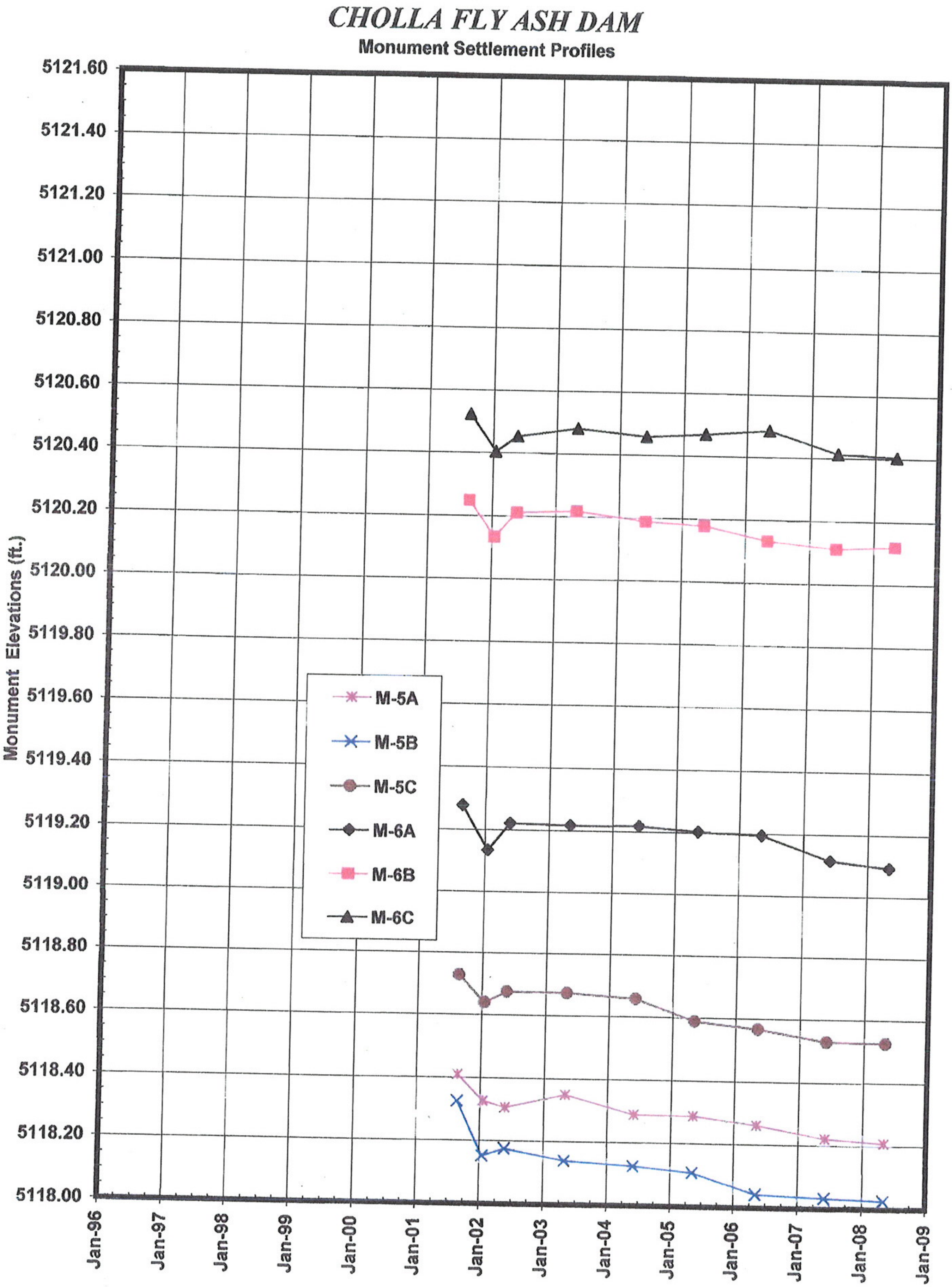
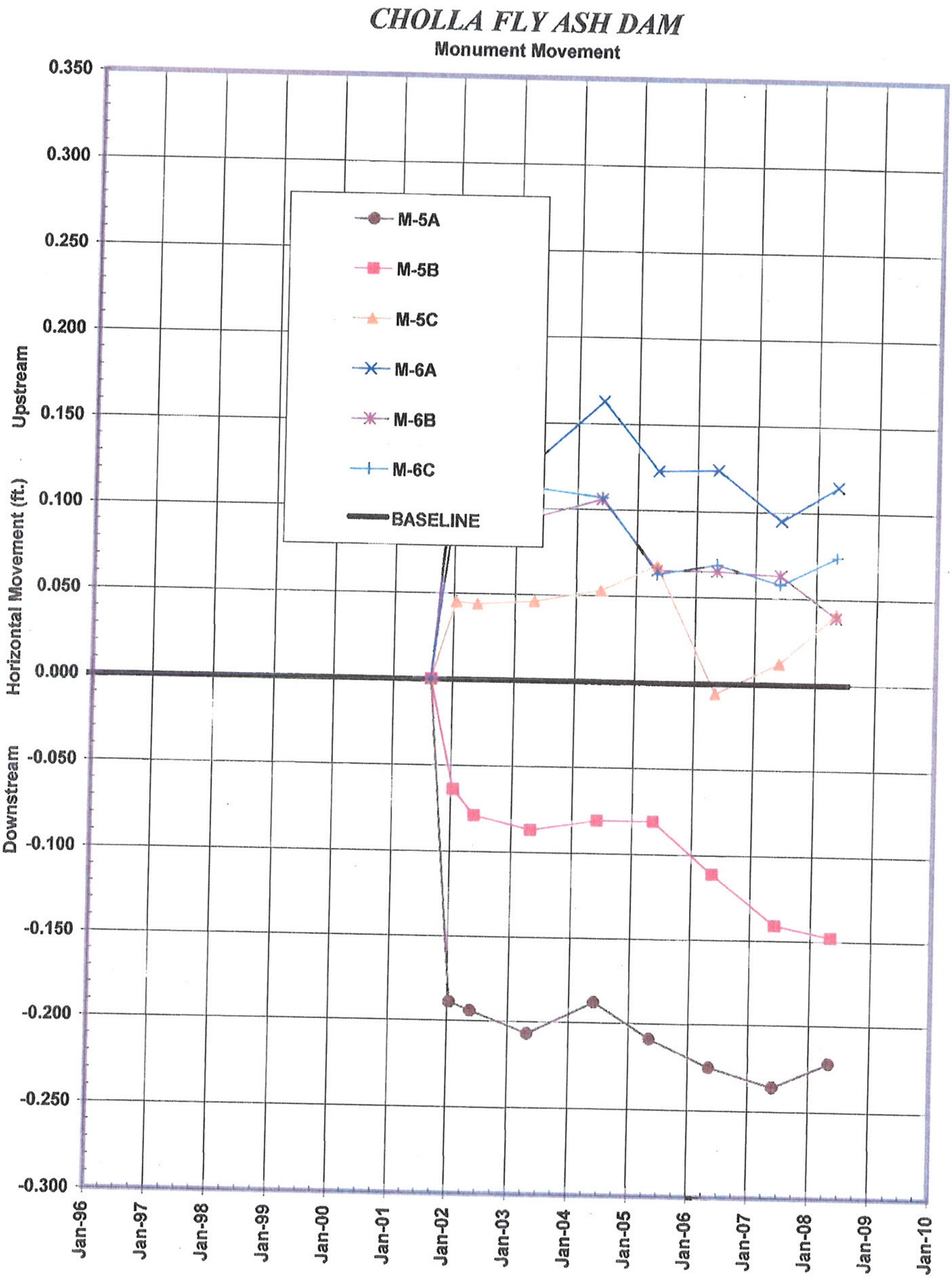
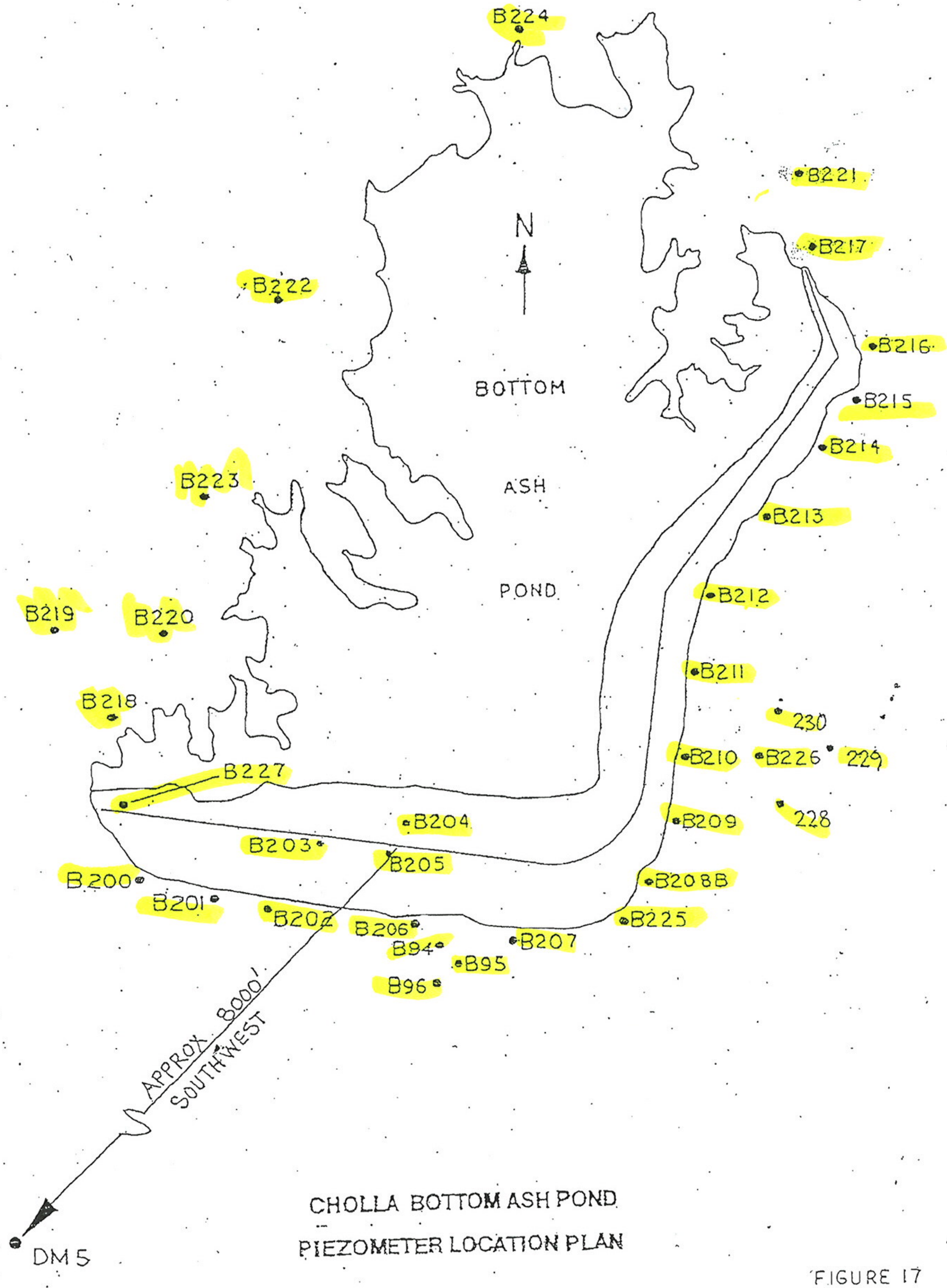

CHOLLA FLY ASH DAM
Monument Settlement Profiles
Monument Elevations (ft.)
5121.60
5121.40
5121.20
5121.00
5120.80
5120.60
5120.40
5120.20
5120.00
5119.80
5119.60
5119.40
5119.20
5119.00
5118.80
5118.60
5118.40
5118.20
5118.00
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
M-5A
M-5B
M-5C
M-6A
M-6B
M-6C

FIGURE 16A



CHOLLA FLY ASH DAM
Monument Movement
Horizontal Movement (ft.)
Upstream
Downstream
0.350
0.300
0.250
0.200
0.150
0.100
0.050
0.000
-0.050
-0.100
-0.150
-0.200
-0.250
-0.300
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10
M-5A
M-5B
M-5C
M-6A
M-6B
M-6C
BASELINE

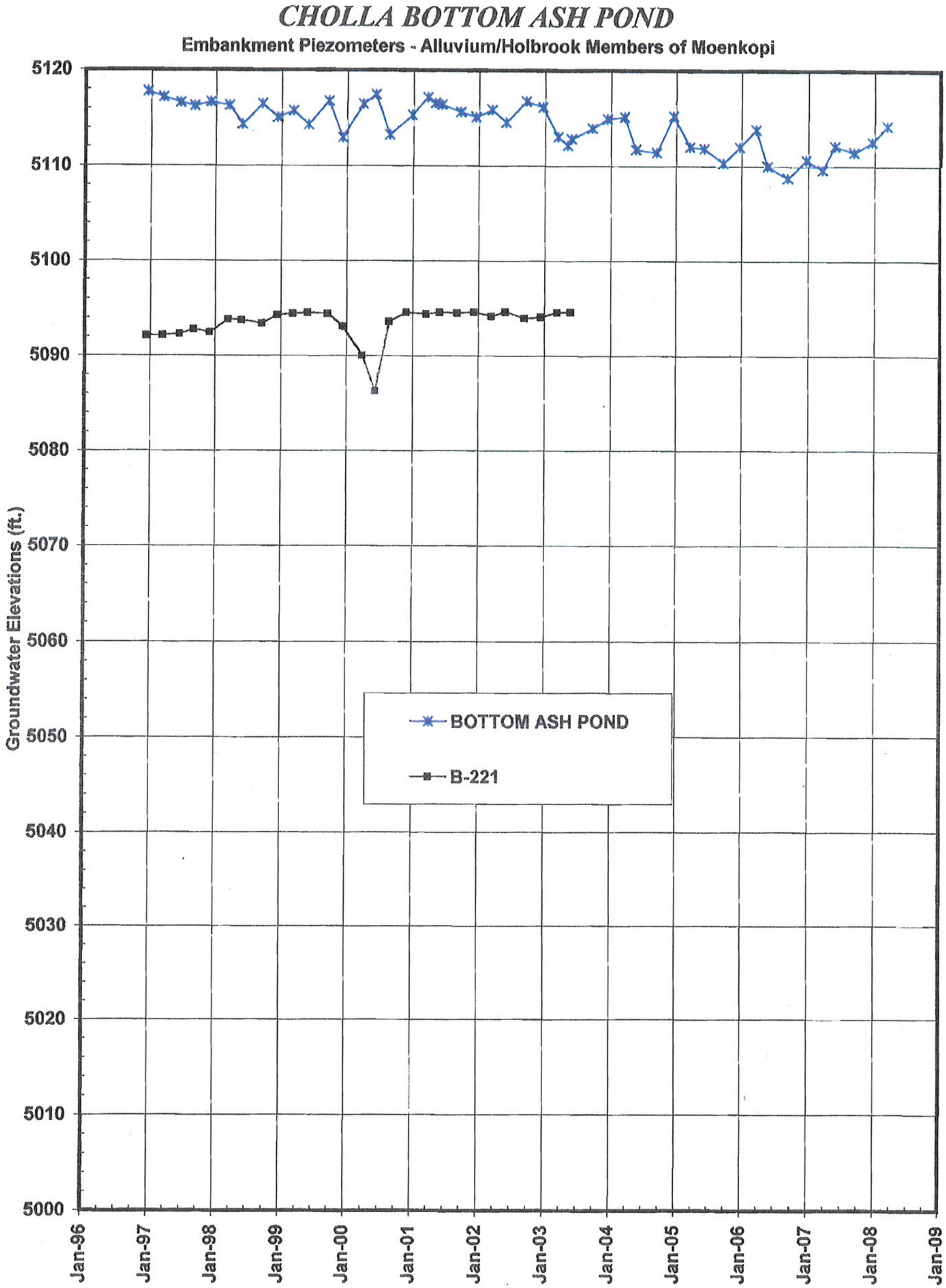
FIGURE 16B



CHOLLA BOTTOM ASH POND

PIEZOMETER LOCATION PLAN

FIGURE 17



CHOLLA BOTTOM ASH POND
Embankment Piezometers - Alluvium/Holbrook Members of Moenkopi
Groundwater Elevations (ft.)
5120
5110
5100
5090
5080
5070
5060
5050
5040
5030
5020
5010
5000
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
BOTTOM ASH POND
B-221

FIGURE 18

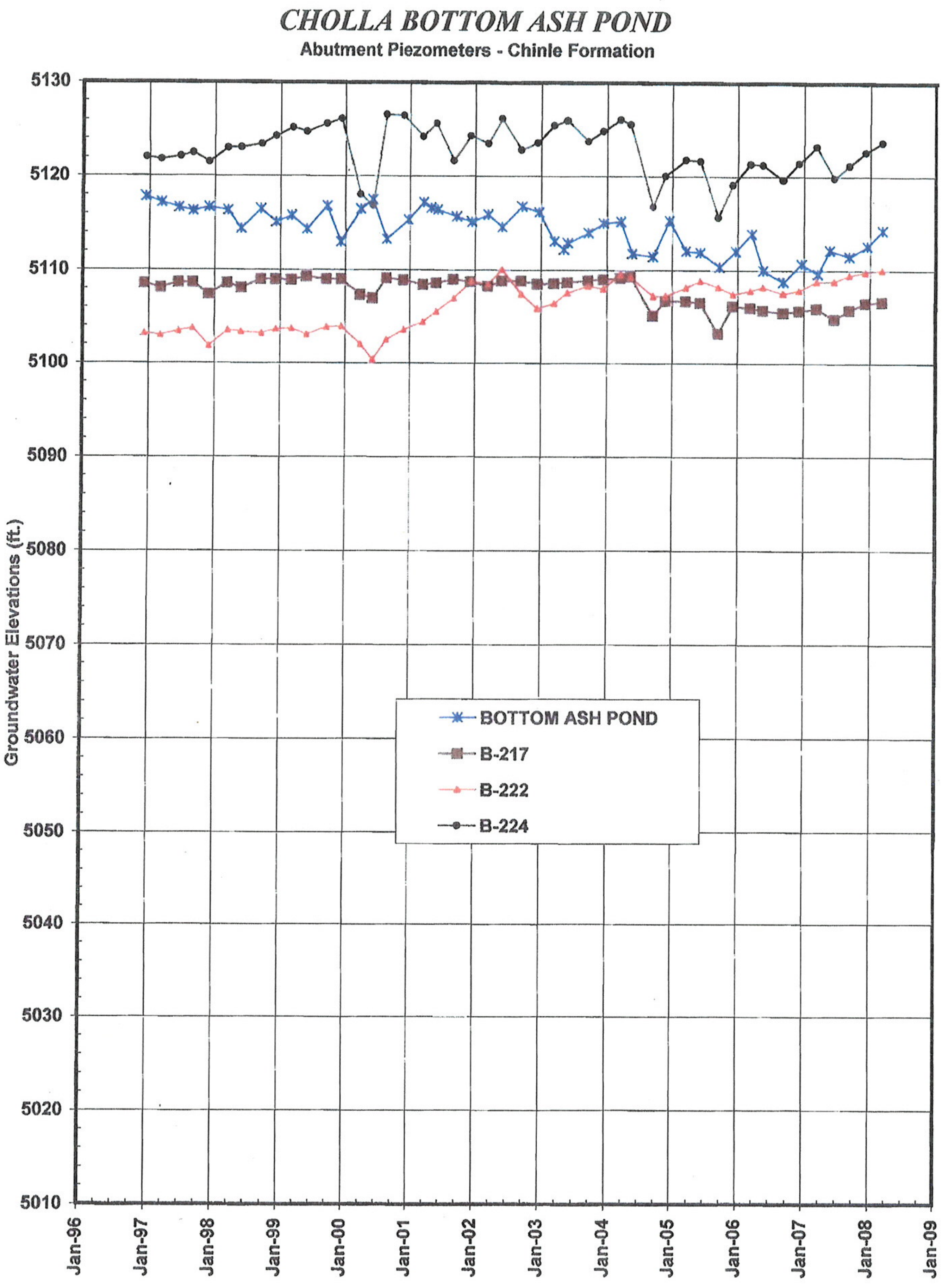

CHOLLA BOTTOM ASH POND
Abutment Piezometers - Chinle Formation
Groundwater Elevations (ft.)
5130
5120
5110
5100
5090
5080
5070
5060
5050
5040
5030
5020
5010
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
BOTTOM ASH POND
B-217
B-222
B-224

FIGURE 19

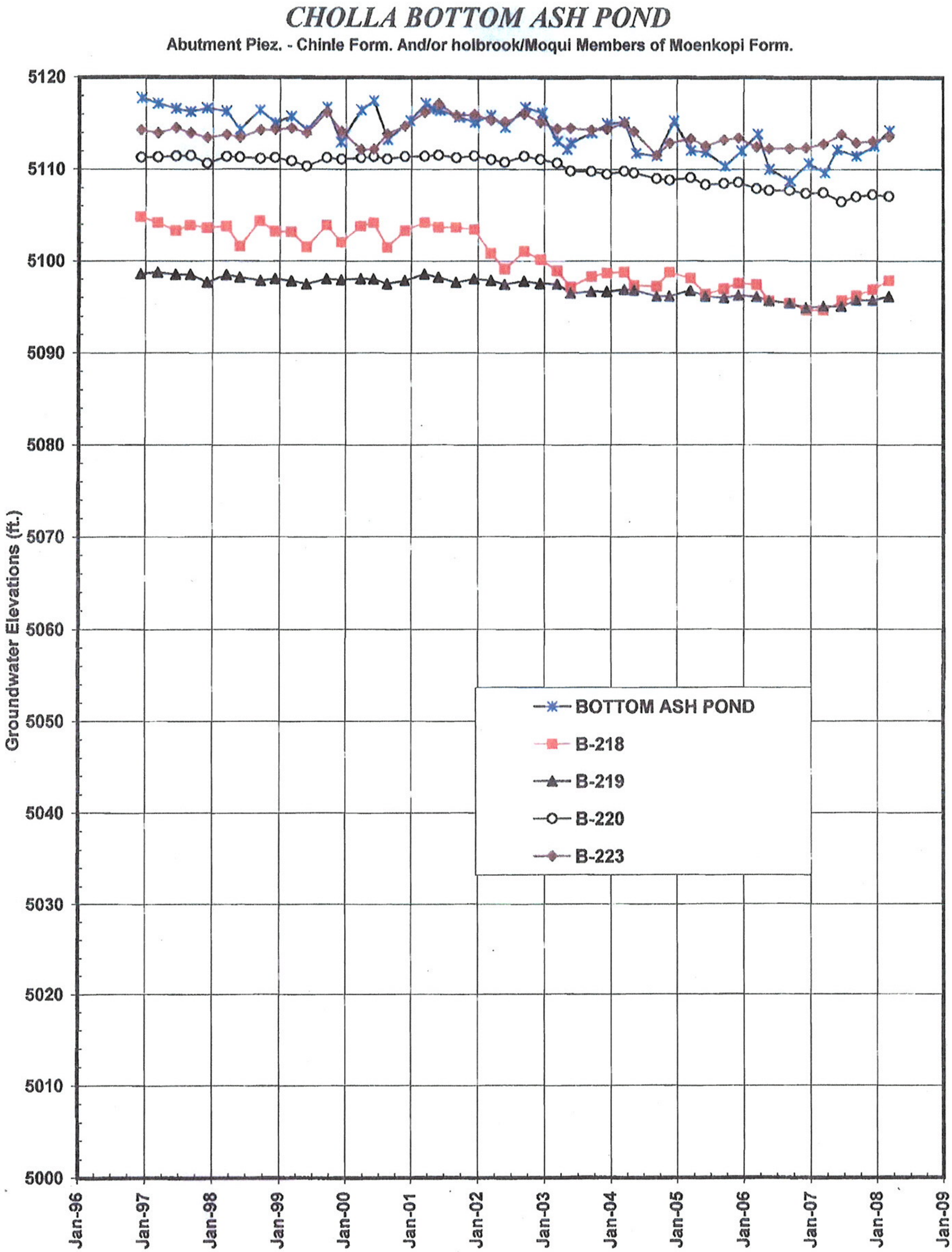

CHOLLA BOTTOM ASH POND
Abutment Piez. - Chinle Form. And/or holbrook/Moqui Members of Moenkopi Form.
Groundwater Elevations (ft.)
5120
5110
5100
5090
5080
5070
5060
5050
5040
5030
5020
5010
5000
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
BOTTOM ASH POND
B-218
B-219
B-220
B-223

FIGURE 20

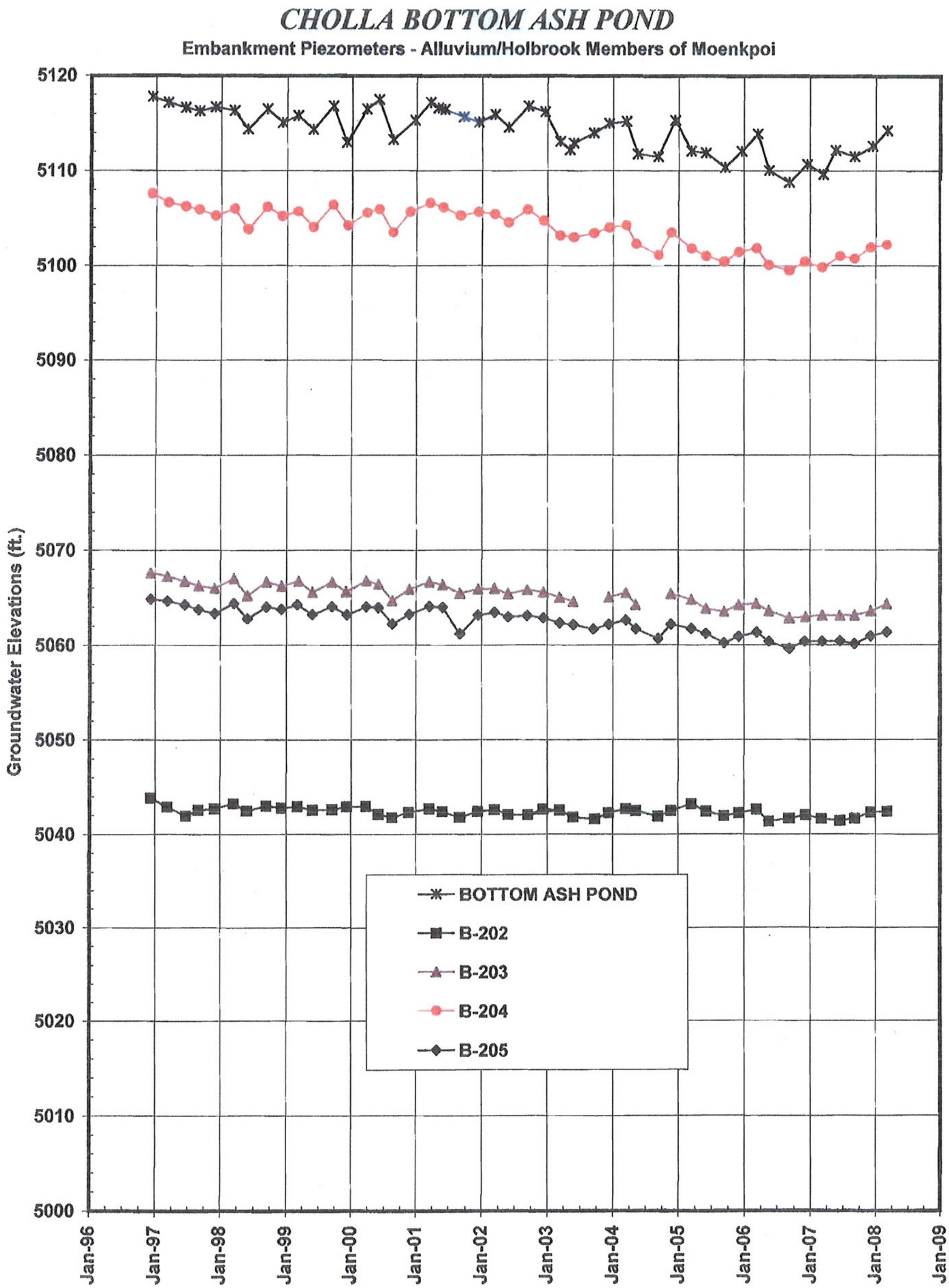
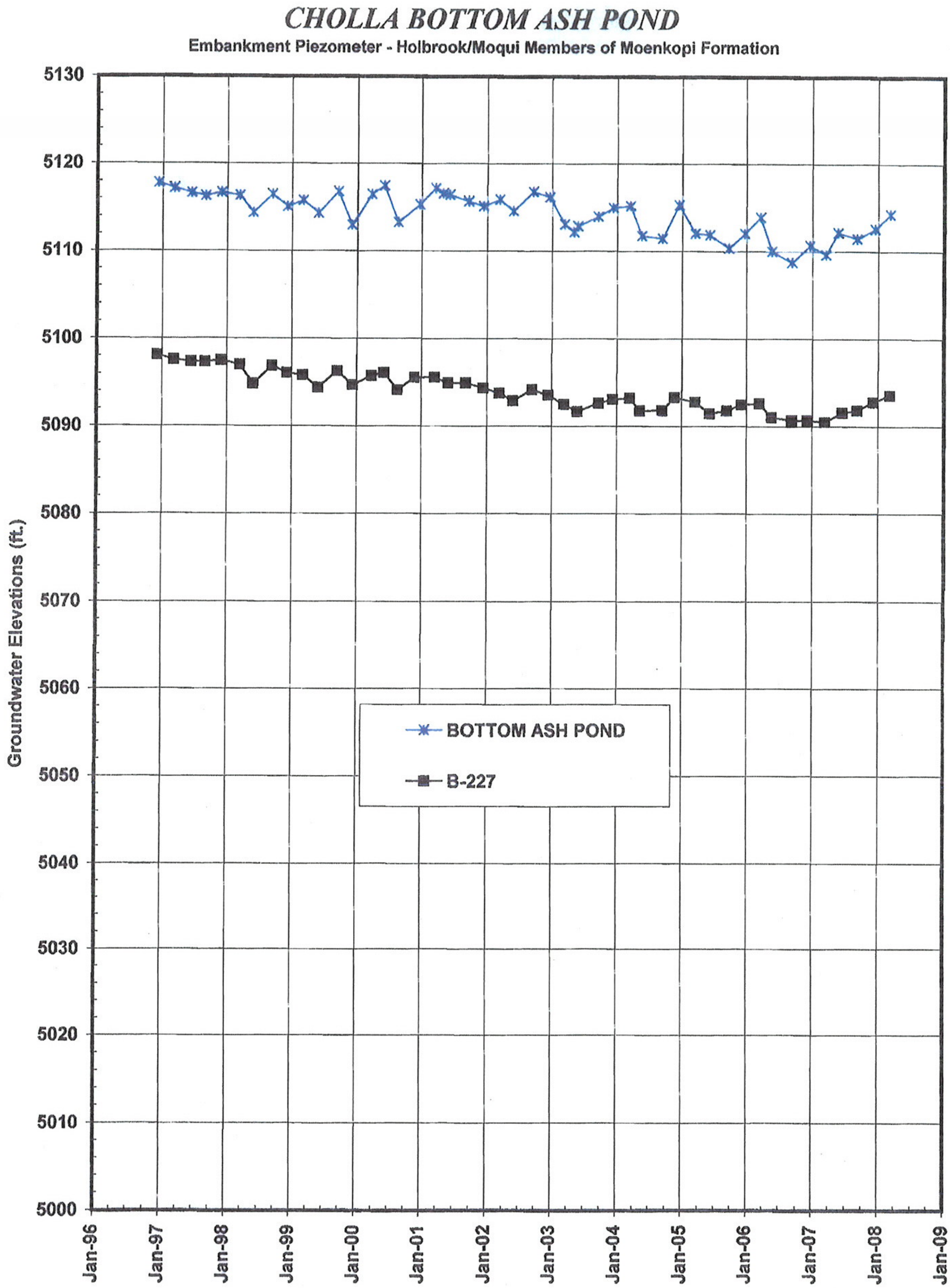

CHOLLA BOTTOM ASH POND
Embankment Piezometers - Alluvium/Holbrook Members of Moenkpoi
Groundwater Elevations (ft.)
5120
5110
5100
5090
5080
5070
5060
5050
5040
5030
5020
5010
5000
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
BOTTOM ASH POND
B-202
B-203
B-204
B-205

FIGURE 21



CHOLLA BOTTOM ASH POND
Embankment Piezometer - Holbrook/Moqui Members of Moenkopi Formation
Groundwater Elevations (ft.)
5130
5120
5110
5100
5090
5080
5070
5060
5050
5040
5030
5020
5010
5000
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
BOTTOM ASH POND
B-227

FIGURE 22

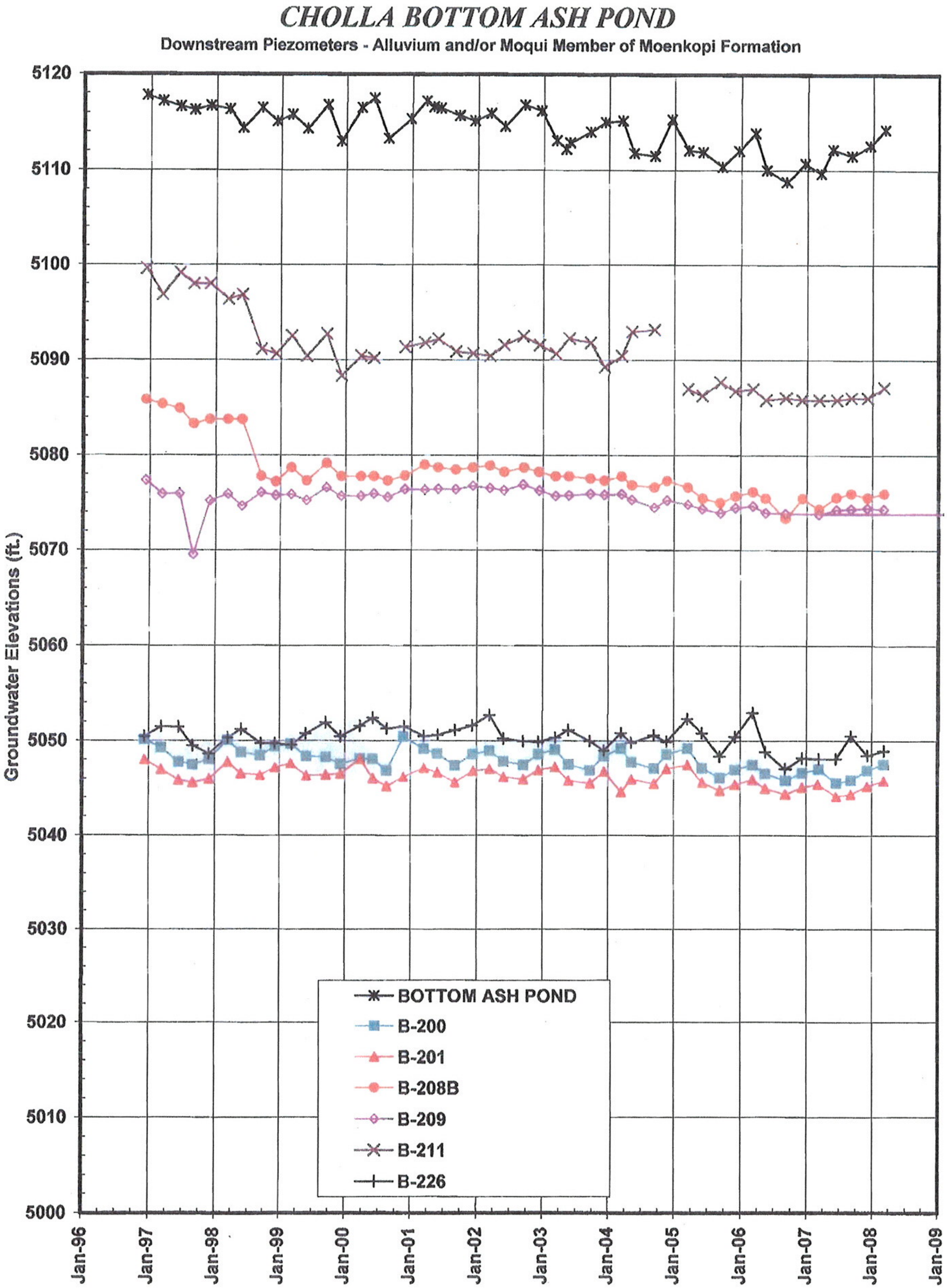
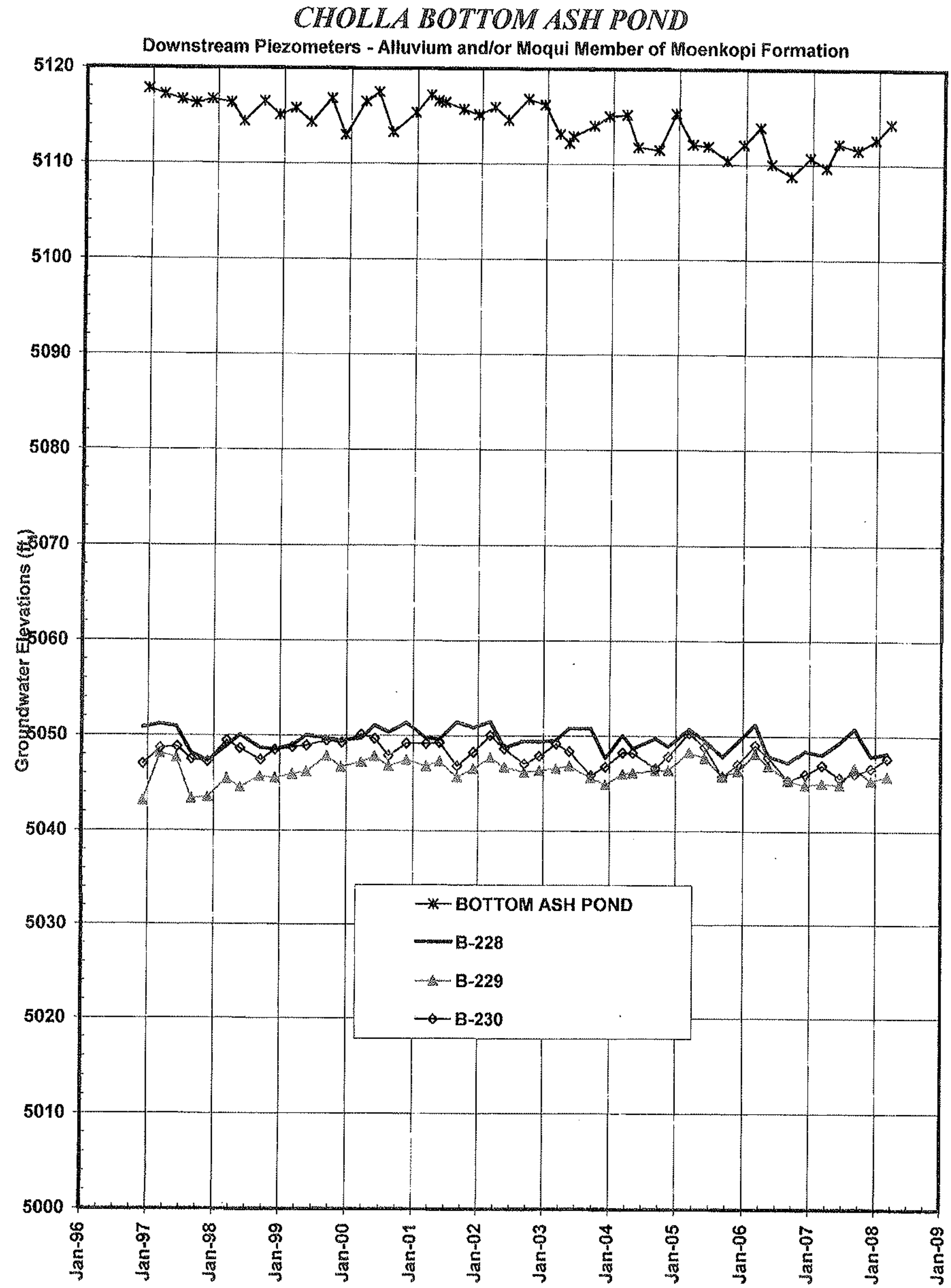
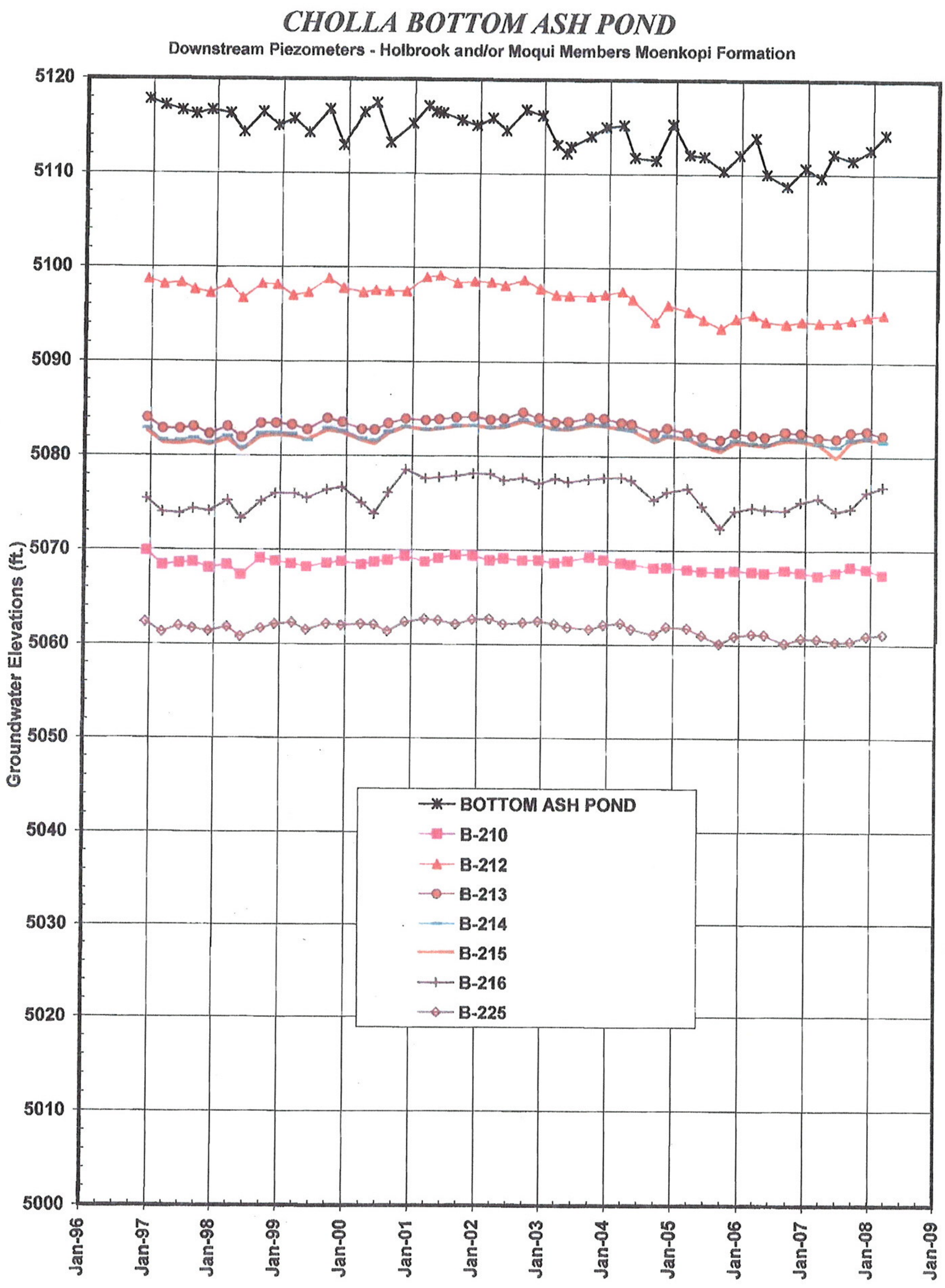

CHOLLA BOTTOM ASH POND
Downstream Piezometers - Alluvium and/or Moqui Member of Moenkopi Formation
Groundwater Elevations (ft.)
5120
5110
5100
5090
5080
5070
5060
5050
5040
5030
5020
5010
5000
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
BOTTOM ASH POND
B-200
B-201
B-208B
B-209
B-211
B-226

FIGURE 23



CHOLLA BOTTOM ASH POND
Downstream Piezometers - Alluvium and/or Moqui Member of Moenkopi Formation
Groundwater Elevations (ft.)
5120
5110
5100
5090
5080
5070
5060
5050
5040
5030
5020
5010
5000
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
BOTTOM ASH POND
B-228
B-229
B-230

FIGURE 23A



CHOLLA BOTTOM ASH POND
Downstream Piezometers - Holbrook and/or Moqui Members Moenkopi Formation
Groundwater Elevations (ft.)
5120
5110
5100
5090
5080
5070
5060
5050
5040
5030
5020
5010
5000
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
BOTTOM ASH POND
B-210
B-212
B-213
B-214
B-215
B-216
B-225

FIGURE 24

CHOLLA BOTTOM ASH POND

Downstream Piezometers - Alluvium and/or Moqui Member of Moenkopi Formation

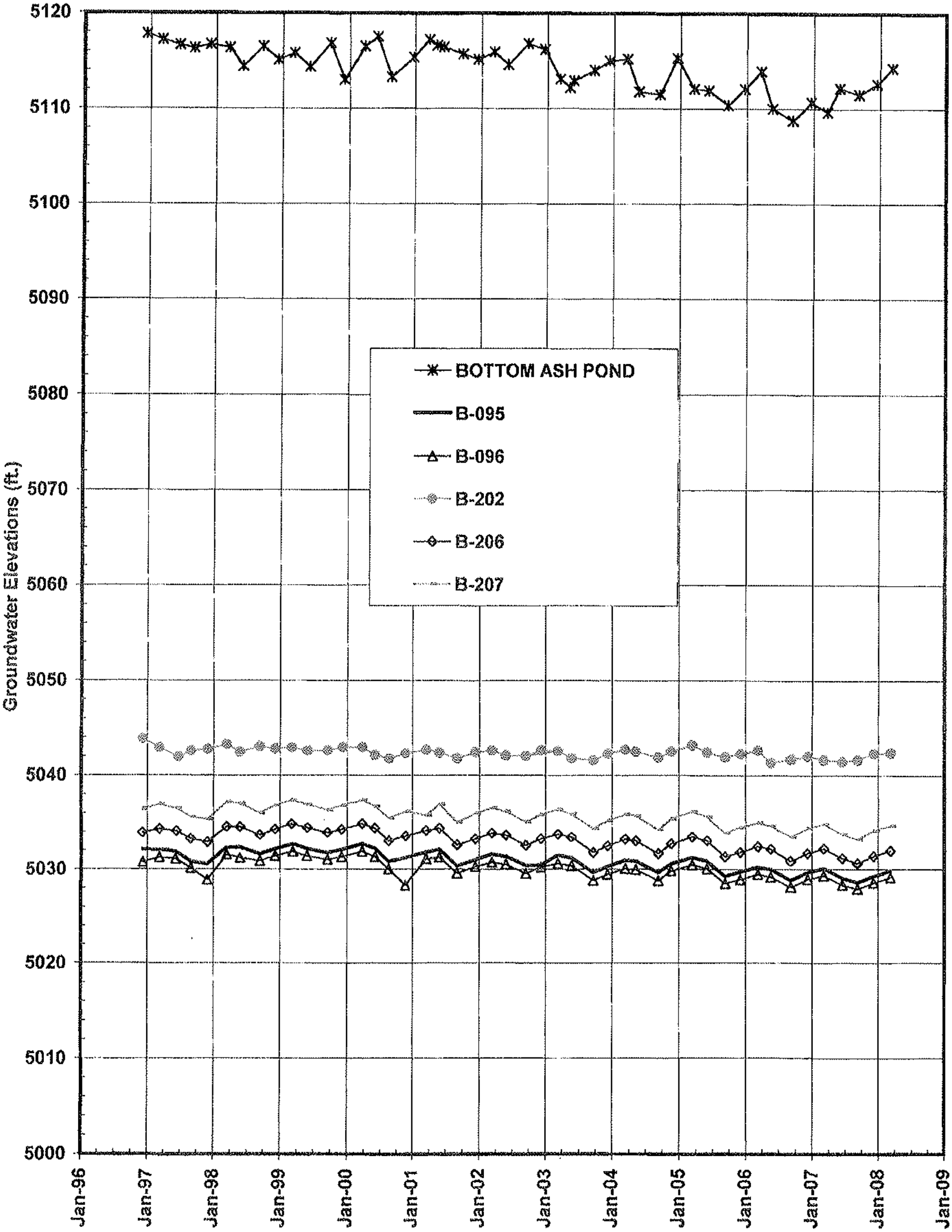


FIGURE 25

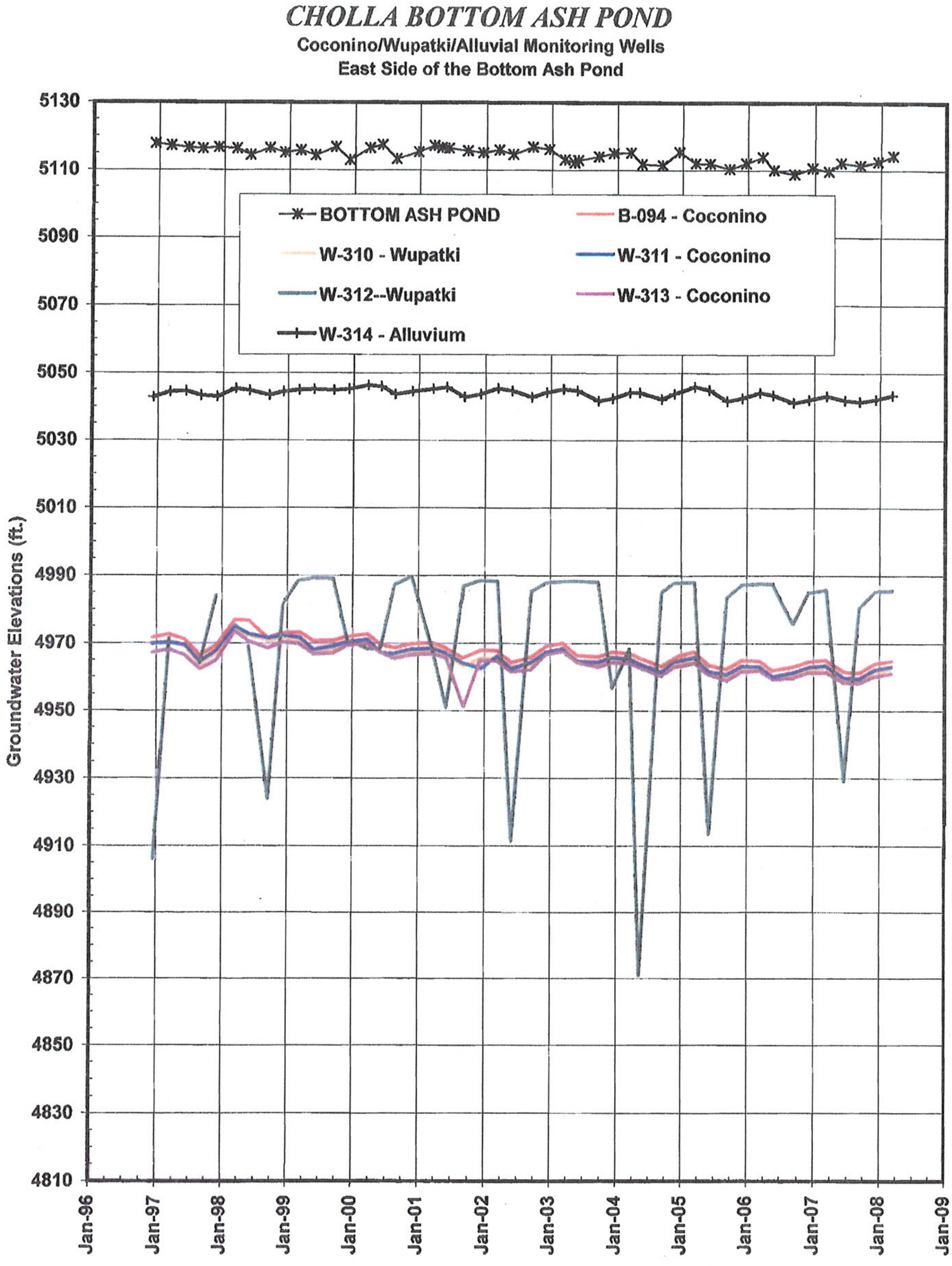

CHOLLA BOTTOM ASH POND
Coconino/Wupatki/Alluvial Monitoring Wells
East Side of the Bottom Ash Pond
BOTTOM ASH POND
B-094 - Coconino
W-310 - Wupatki
W-311 - Coconino
W-312--Wupatki
W-313 - Coconino
W-314 - Alluvium
Groundwater Elevations (ft.)
5130
5110
5090
5070
5050
5030
5010
4990
4970
4950
4930
4910
4890
4870
4850
4830
4810
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09

FIGURE 25A

CHOLLA BOTTOM ASH POND

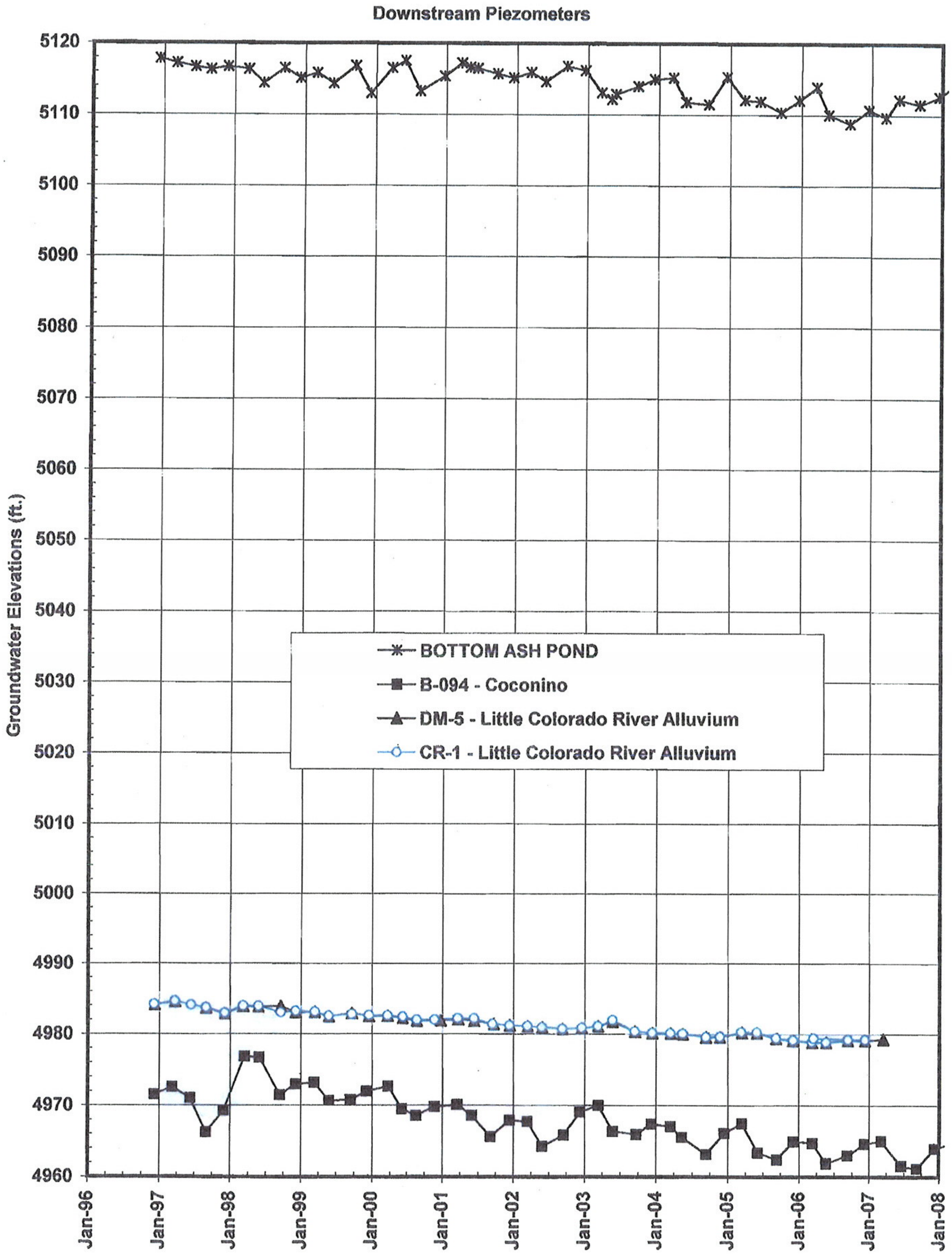
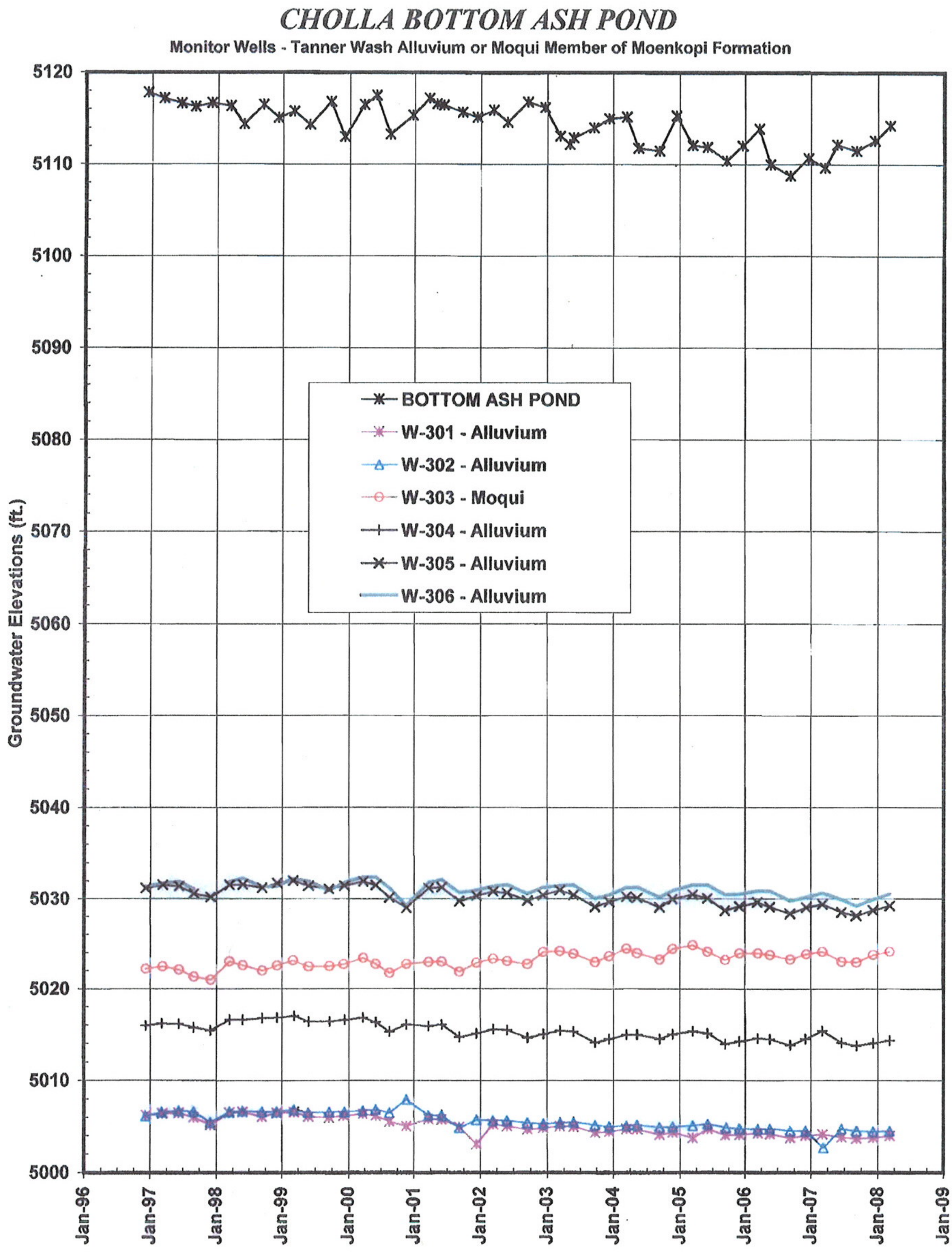


FIGURE 26



CHOLLA BOTTOM ASH POND
Monitor Wells - Tanner Wash Alluvium or Moqui Member of Moenkopi Formation
Groundwater Elevations (ft.)
5120
5110
5100
5090
5080
5070
5060
5050
5040
5030
5020
5010
5000
BOTTOM ASH POND
W-301 - Alluvium
W-302 - Alluvium
W-303 - Moqui
W-304 - Alluvium
W-305 - Alluvium
W-306 - Alluvium
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09

FIGURE 28

CHOLLA BOTTOM ASH POND

Monitor Wells - Tanner Wash Alluvium

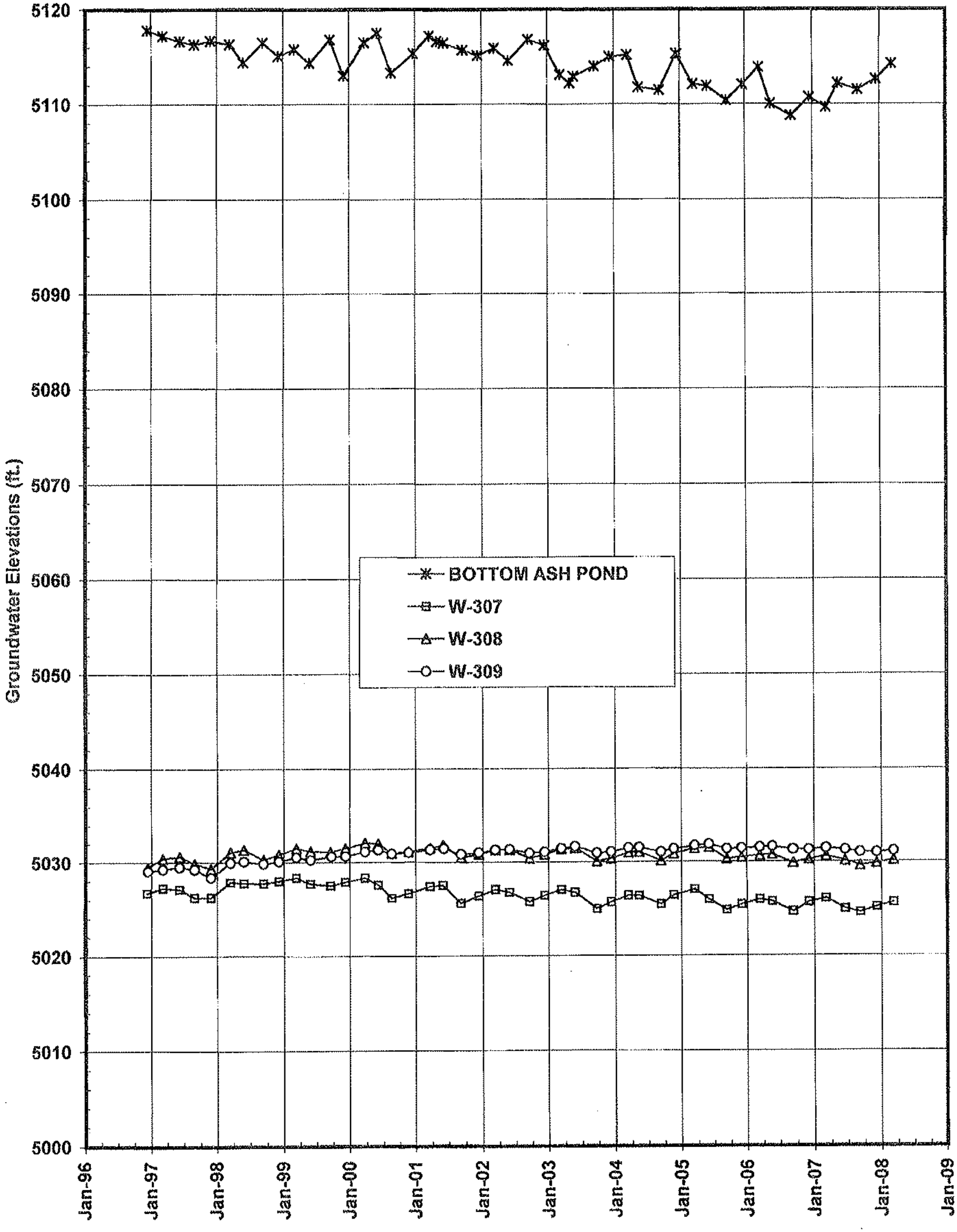
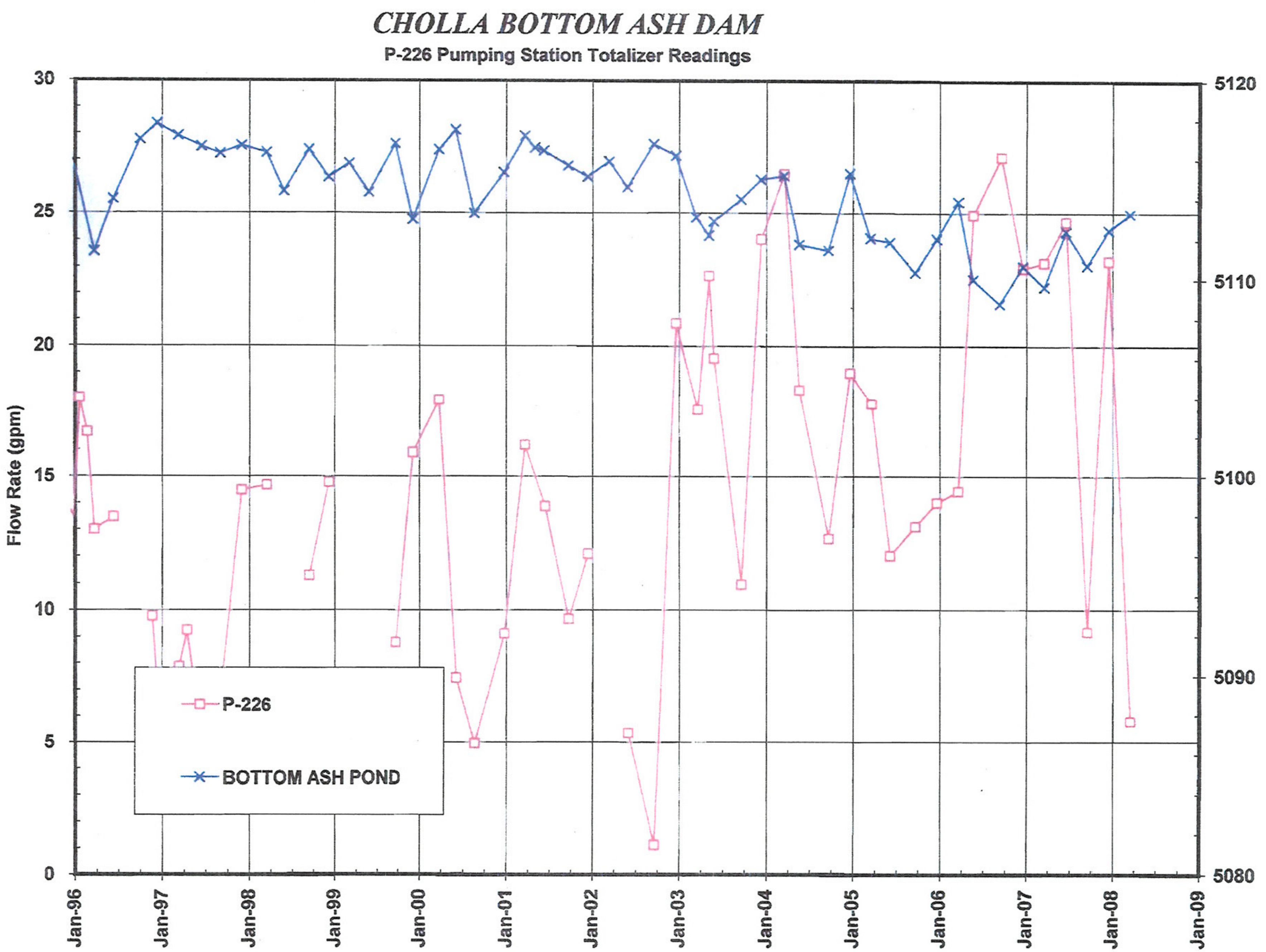
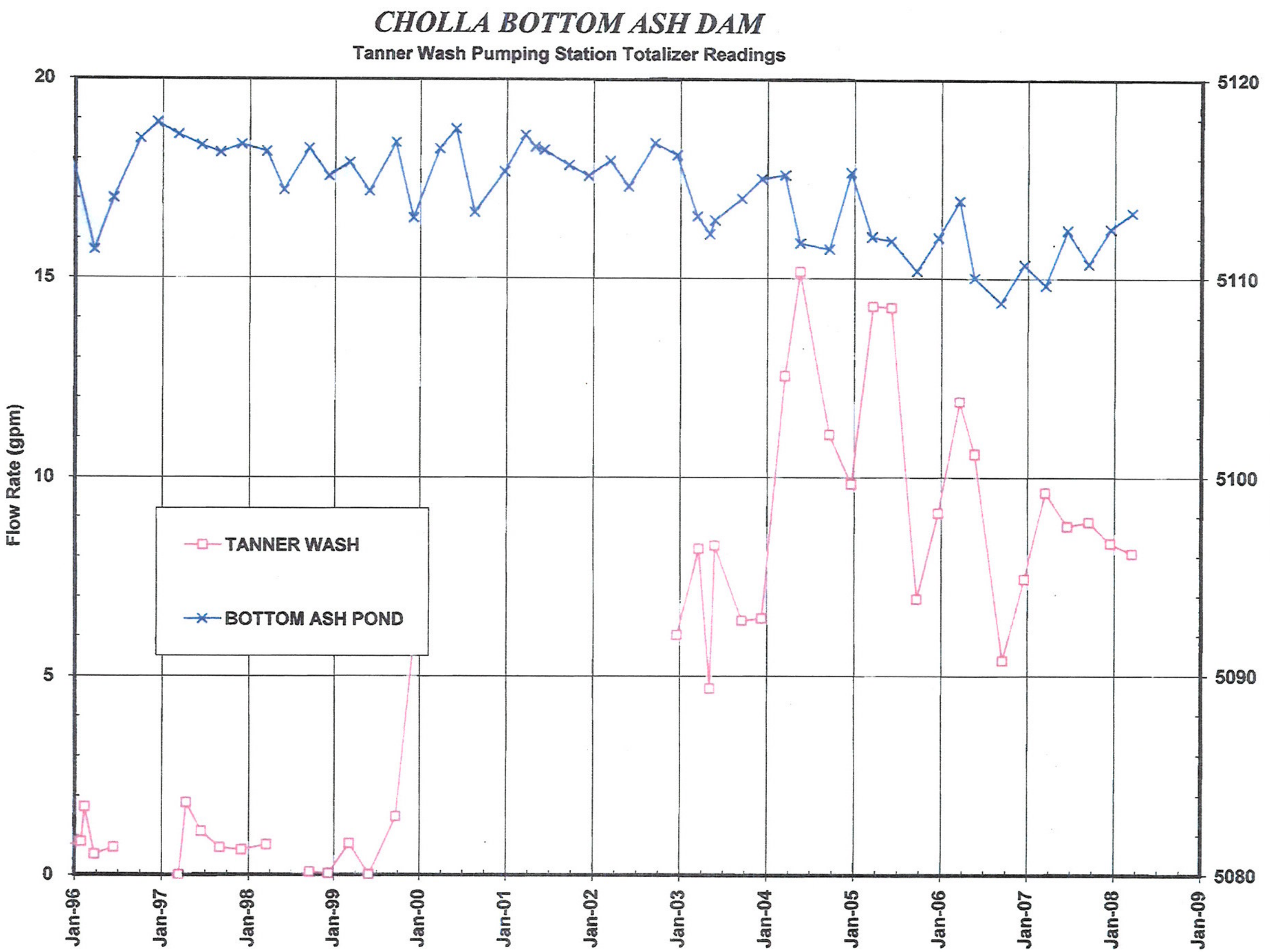


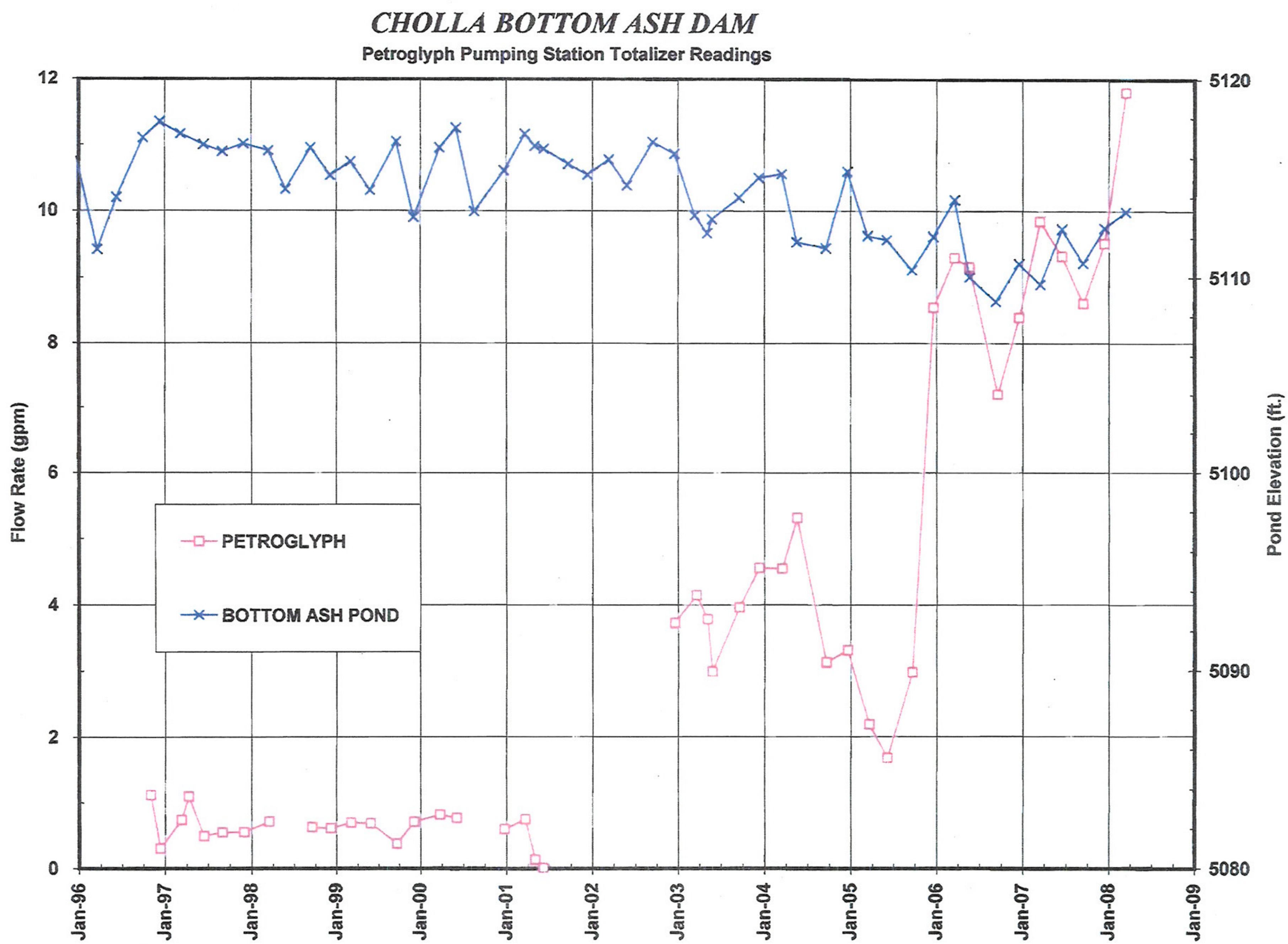
FIGURE 29


CHOLLA BOTTOM ASH DAM
P-226 Pumping Station Totalizer Readings
Flow Rate (gpm)
Pond Elevation (ft.)
30
25
20
15
10
5
0
5120
5110
5100
5090
5080
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
P-226
BOTTOM ASH POND

GRAPH 31A


CHOLLA BOTTOM ASH DAM
Tanner Wash Pumping Station Totalizer Readings
Flow Rate (gpm)
Pond Elevation (ft.)
20
15
10
5
0
5120
5110
5100
5090
5080
TANNER WASH
BOTTOM ASH POND
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09

GRAPH 31C

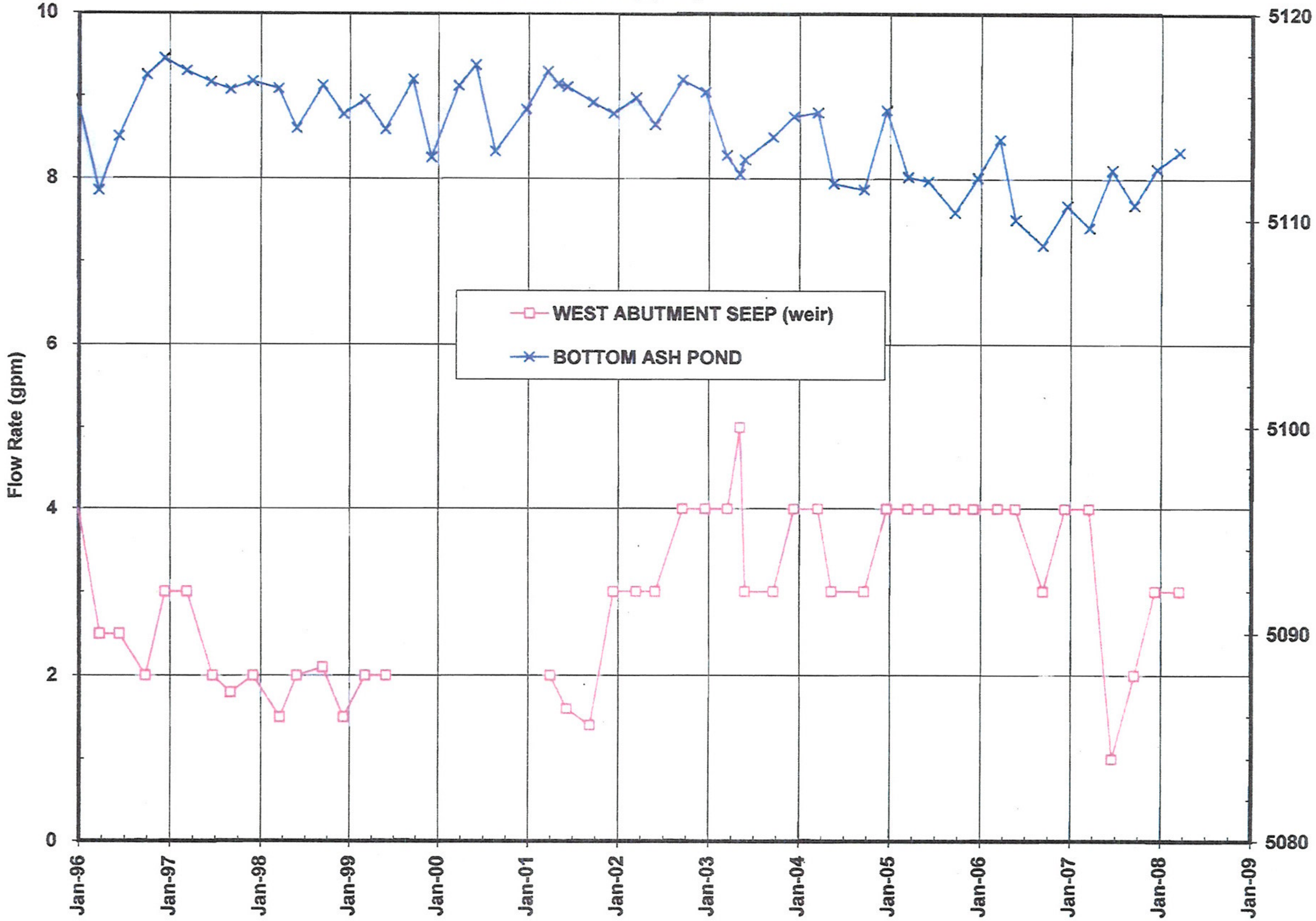


CHOLLA BOTTOM ASH DAM
Petroglyph Pumping Station Totalizer Readings
Flow Rate (gpm)
Pond Elevation (ft.)
PETROGLYPH
BOTTOM ASH POND
0
2
4
6
8
10
12
5080
5090
5100
5110
5120
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09

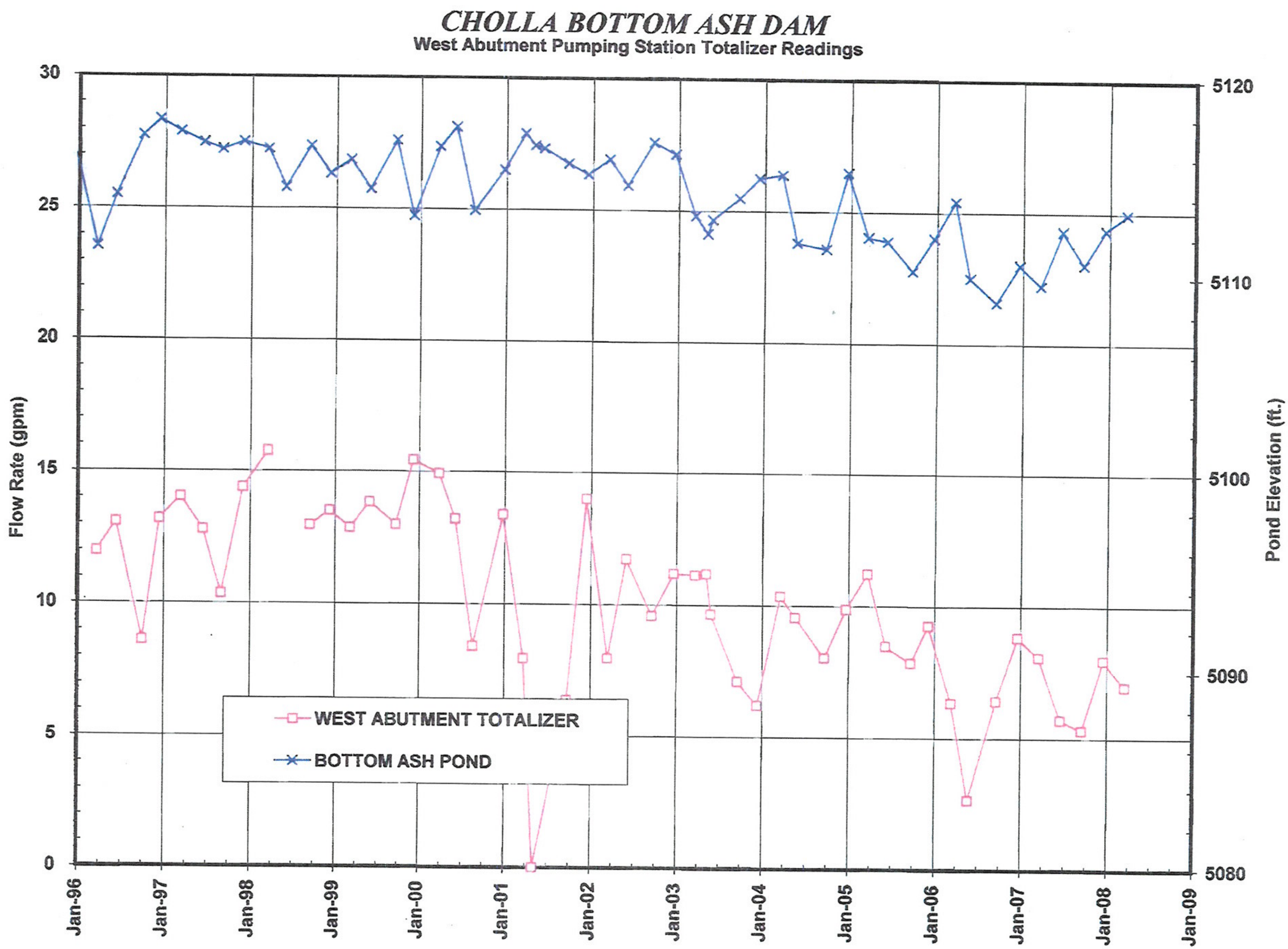
GRAPH 31B

CHOLLA BOTTOM ASH DAM

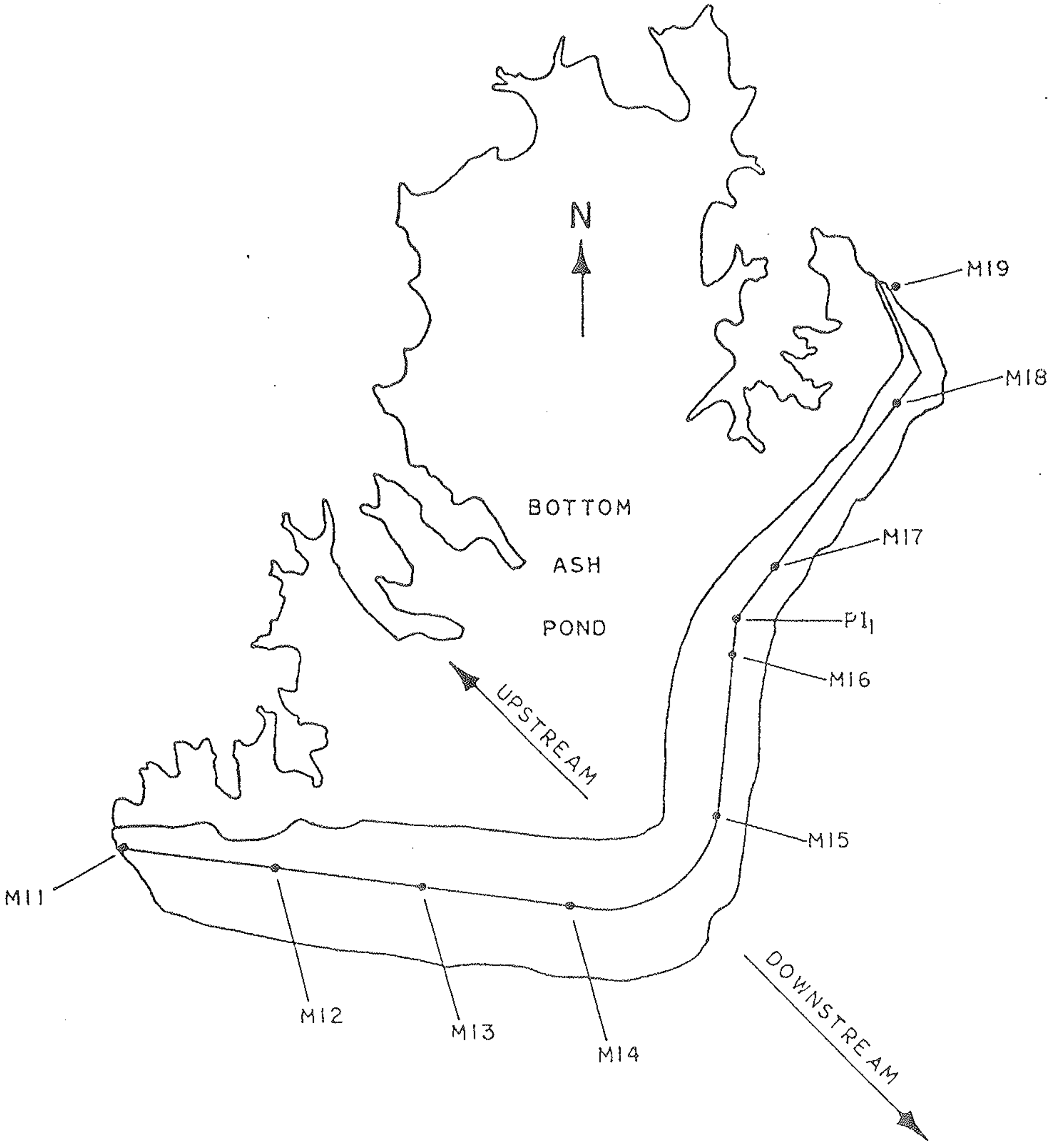
West Abutment Seep (weir)



GRAPH 32


CHOLLA BOTTOM ASH DAM
West Abutment Pumping Station Totalizer Readings
Flow Rate (gpm)
Pond Elevation (ft.)
WEST ABUTMENT TOTALIZER
BOTTOM ASH POND
30
25
20
15
10
5
0
5120
5110
5100
5090
5080
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09

GRAPH 36



CHOLLA BOTTOM ASH POND

MONUMENT LOCATION PLAN

FIGURE 37

CH079679

CHOLLA BOTTOM ASH DAM

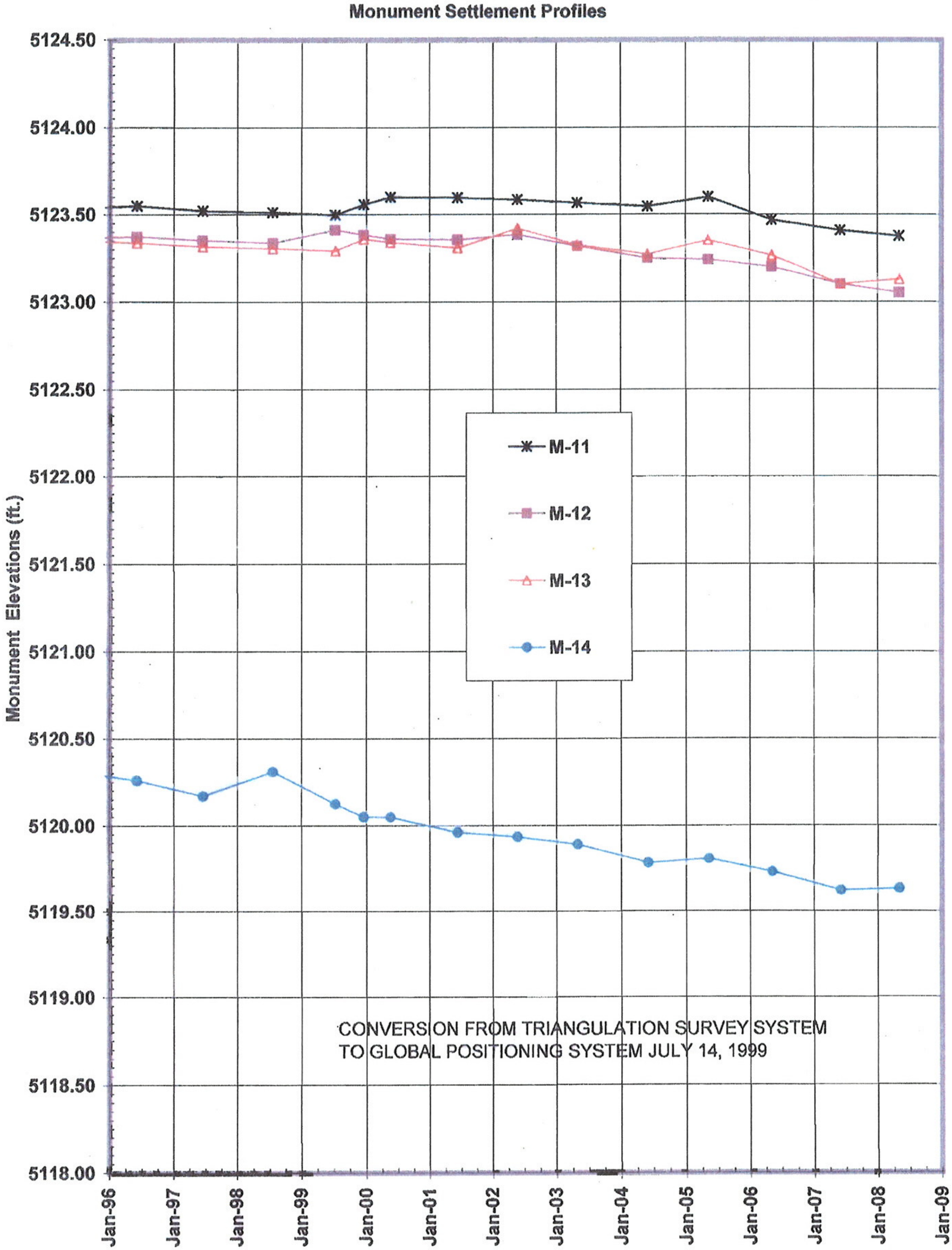
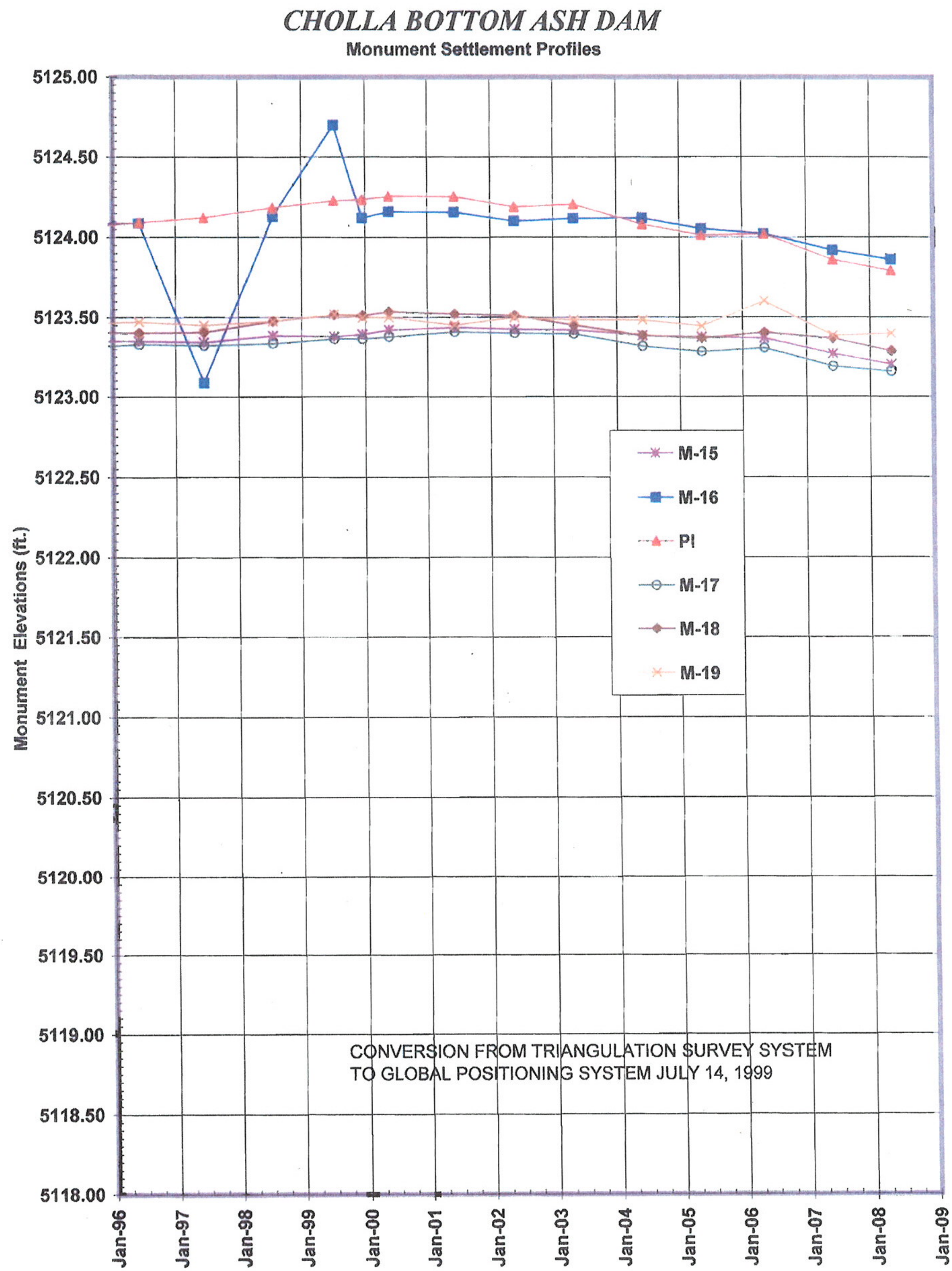
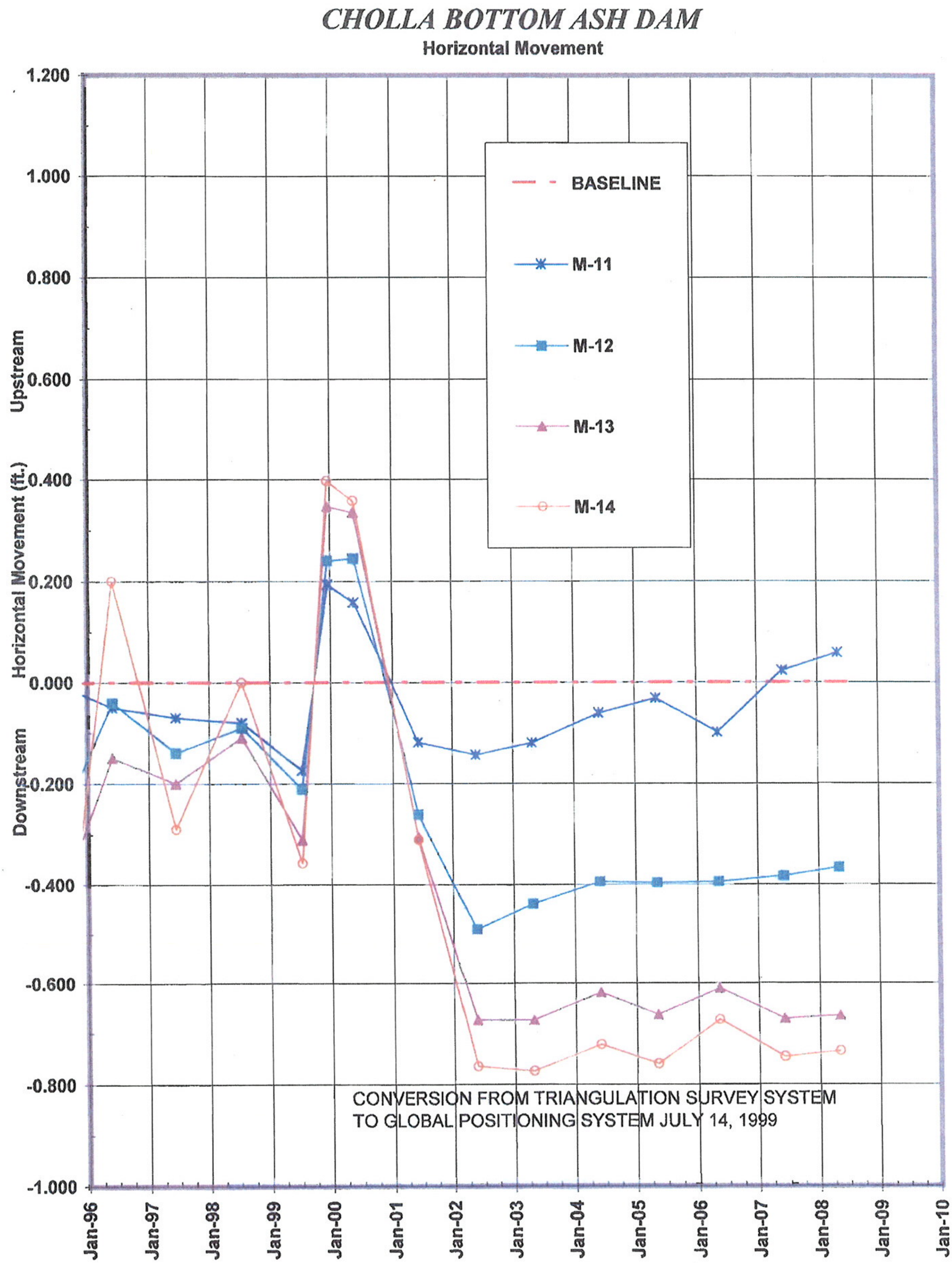


FIGURE 38



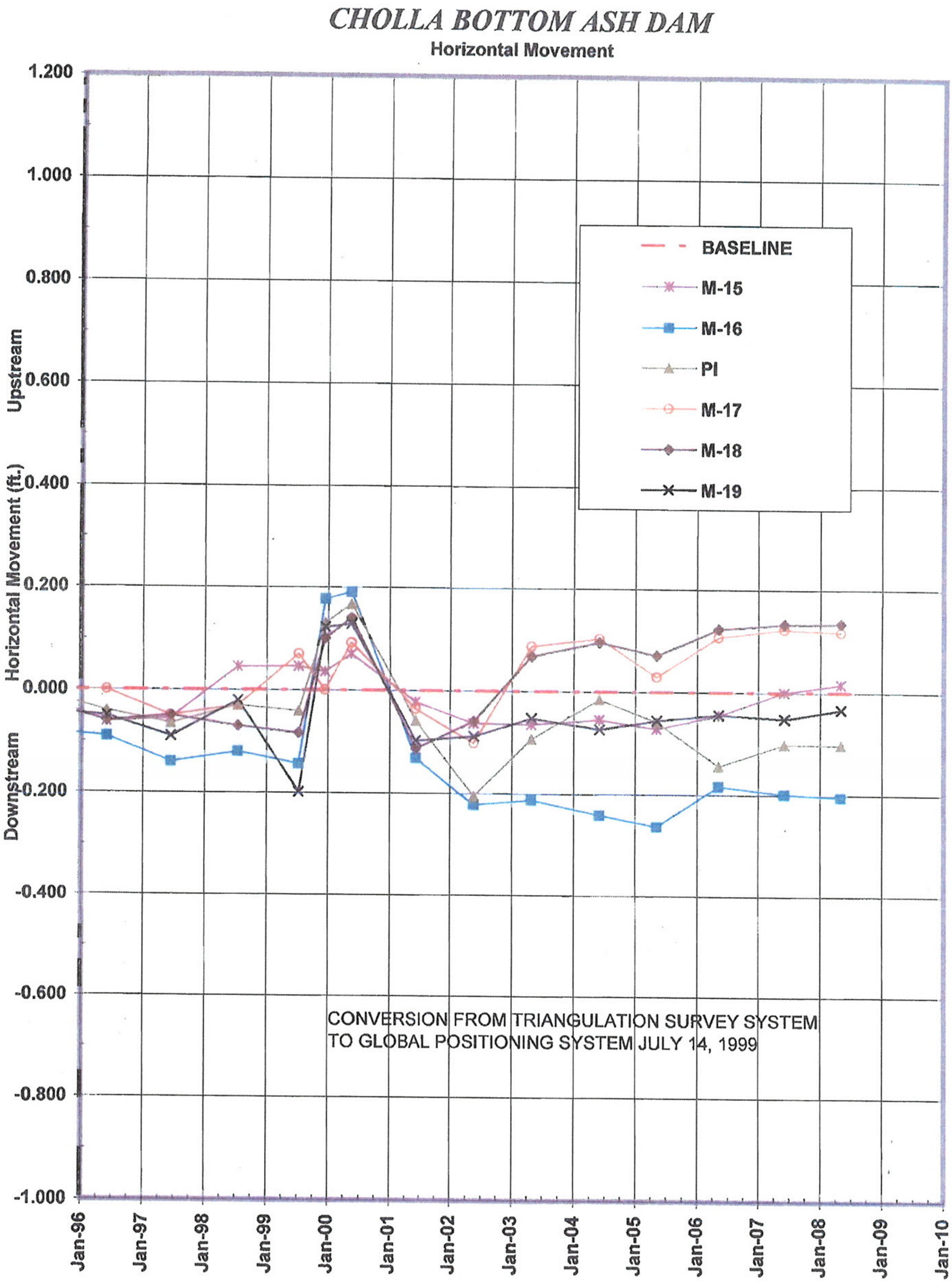
CHOLLA BOTTOM ASH DAM
Monument Settlement Profiles
Monument Elevations (ft.)
5125.00
5124.50
5124.00
5123.50
5123.00
5122.50
5122.00
5121.50
5121.00
5120.50
5120.00
5119.50
5119.00
5118.50
5118.00
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
M-15
M-16
PI
M-17
M-18
M-19
CONVERSION FROM TRIANGULATION SURVEY SYSTEM
TO GLOBAL POSITIONING SYSTEM JULY 14, 1999

FIGURE 39



CHOLLA BOTTOM ASH DAM
Horizontal Movement
Upstream
Horizontal Movement (ft.)
Downstream
1.200
1.000
0.800
0.600
0.400
0.200
0.000
-0.200
-0.400
-0.600
-0.800
-1.000
BASELINE
M-11
M-12
M-13
M-14
CONVERSION FROM TRIANGULATION SURVEY SYSTEM
TO GLOBAL POSITIONING SYSTEM JULY 14, 1999
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10

FIGURE 40



CHOLLA BOTTOM ASH DAM
Horizontal Movement
Horizontal Movement (ft.)
Upstream
Downstream
1.200
1.000
0.800
0.600
0.400
0.200
0.000
-0.200
-0.400
-0.600
-0.800
-1.000
BASELINE
M-15
M-16
PI
M-17
M-18
M-19
CONVERSION FROM TRIANGULATION SURVEY SYSTEM
TO GLOBAL POSITIONING SYSTEM JULY 14, 1999
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10

FIGURE 40A

Appendix B

Inspection Checklists

September 2, 2009

Site Name: **Cholla Generating Station, Joseph City, AZ** Date: **Sept 2, 2009**

Unit Name: **Fly Ash Pond Dam** Operator's Name: **Arizona Public Service**

Unit ID: Hazard Potential Classification: **High** Significant Low

Inspector's Name: **Steve Townsley/GEI Consultants, Mary Nodine/GEI Consultants**

Check the appropriate box below, Provide comments when appropriate. If not applicable or not available, record "N/A", Any unusual conditions or construction practices that should be noted in the comments section, For large diked embankments, separate checklists may be used for different embankment areas. If separate forms are used, identify approximate area that the form applies to in comments.

	Yes	No		Yes	No
1. Frequency of Company's Dam Inspections?	Annual		18. Sloughing or bulging on slopes?		X
2. Pool elevation (operator records)?	5093.2		19. Major erosion or slope deterioration?		X
3. Decant inlet elevation (operator records)?	NA		20. Decant Pipes		
4. Open channel spillway elevation (operator records)?	NA		Is water entering inlet, but not exiting outlet?		X
5. Lowest dam crest elevation (operator records)?	5120		Is water exiting outlet, but not entering inlet?		X
6. If instrumentation is present, are readings recorded (operator records)?	X		Is water exiting outlet flowing clear?	NA	
7. Is the embankment currently under construction?		X	21. Seepage (specify location, if seepage carries fines, and approximate seepage rate below):		
8. Foundation preparation (remove vegetation, stumps, topsoil in area where embankment fill will be placed)?		X	From underdrain?		X
9. Trees growing on embankment? (If so, indicate largest diameter below.)		X	At isolated points on embankment slopes?		X
10. Cracks or scarps on crest?		X	At natural hillside in the embankment area?		X
11. Is there significant settlement along the crest?		X	Over widespread areas?		X
12. Are decant trashracks clear and in place?	NA		From downstream foundation area?	X	
13. Depressions or sink holes in tailings surface or whirlpool in the pool area		X	"Boils" beneath stream or ponded water?		X
14. Clogged spillways, groin or diversion ditches?		X	Around the outside of the decant pipe?		X
15. Are spillway or ditch linings deteriorated?		X	22. Surface movements in valley bottom or on hillside?		X
16. Are outlets of decant or underdrains blocked?		X	23. Water against downstream toe?		X
17. Cracks or scarps on slopes		X	24. Were Photos taken during the dam inspection?	X	

Major adverse changes in these items could cause instability and should be reported for further evaluation. Adverse conditions noted in these items should normally be described (extent, location, volume, etc.) in the space below and on the back of this sheet.

Inspection Issue #	Comments
21. Seepage locations beyond dam toe	**See discussion page 7**
9. Vegetation on upstream and downstream slopes	**Brush should be cleared during routine maintenance**

Coal Combustion Waste (CCW)
Impoundment Inspection

Impoundment NPDES Permit # NA INSPECTOR Steve Townsley/GEI

Date Sept 2, 2009

Impoundment Name Fly Ash Pond Dam, Cholla Generating Station, Joseph City, AZ

Impoundment Company Arizona Public Service

EPA Region 6

State Agency (Field Office) Address 2225 W. Peoria Avenue, Phoenix, AZ 85029-4929

Name of Impoundment Fly Ash Pond Dam
(Report each impoundment on a separate form under the same Impoundment NPDES Permit number)

New X Update ______

	Yes	No
Is impoundment currently under construction?		X
Is water or ccw currently being pumped into the impoundment?	X	

IMPOUNDMENT FUNCTION: Fly Ash and Decant Water Storage

Nearest Downstream Town: Name Joseph City
Distance from the impoundment 4 miles

Impoundment Location:							
	Longitude	34	Degrees	57	Minutes	22	Seconds
	Latitude	110	Degrees	20	Minutes	5	Seconds
	State	AZ	County	Navajo			

Does a state agency regulate this impoundment? YES X NO ______

If So Which Sate Agency? Arizona Department of Water Resources

<u>HAZARD POTENTIAL</u> (In the event the impoundment should fail, the following would occur):

______ **LESS THAN LOW** HAZARD POTENTIAL: Failure or misoperation of the dam results in no probable loss of human life or economic or environmental losses.

______ **LOW HAZARD POTENTIAL:** Dams assigned the low hazard potential classification are those where failure or misoperation results in no probable loss of human life and low economic and/or environmental losses. Losses are principally limited to the owner's property.

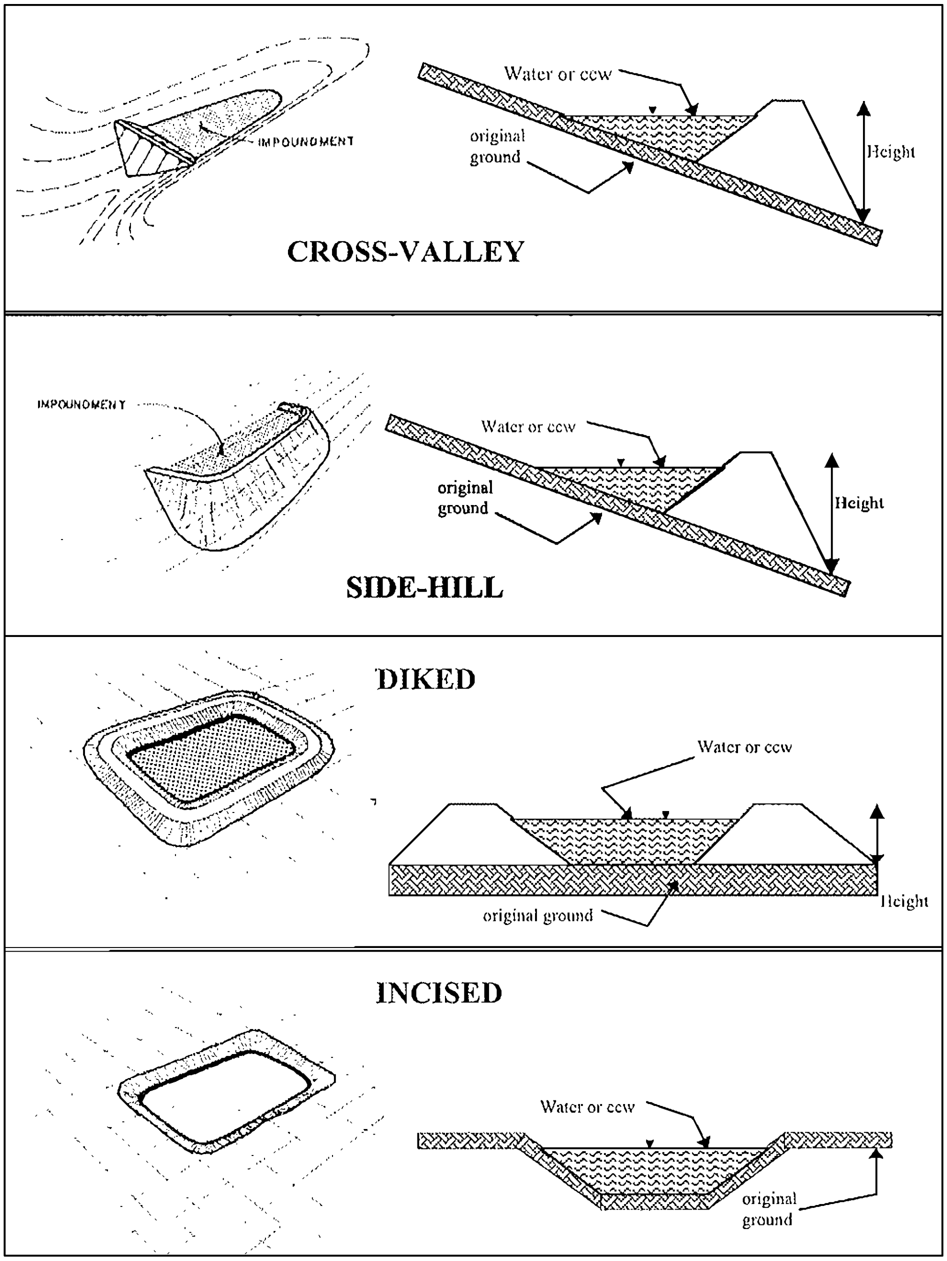
______ **SIGNIFICANT HAZARD POTENTIAL:** Dams assigned the significant hazard potential classification are those dams where failure or misoperation results in no probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities, or can impact other concerns. Significant hazard potential classification dams are often located in predominantly rural or agricultural areas but could be located in areas with population and significant infrastructure.

__X___ **HIGH HAZARD POTENTIAL:** Dams assigned the high hazard potential classification are those where failure or misoperation will probably cause loss of human life.

DESCRIBE REASONING FOR HAZARD RATING CHOSEN:

A failure of the dam may cause inundation of Interstate 40, a freight railroad line and the APS Cholla Power Plant, all located just downstream of the Fly Ash Pond Dam. Flooding of these facilities would certainly cause significant economic losses and would likely cause loss of life.

CONFIGURATION:



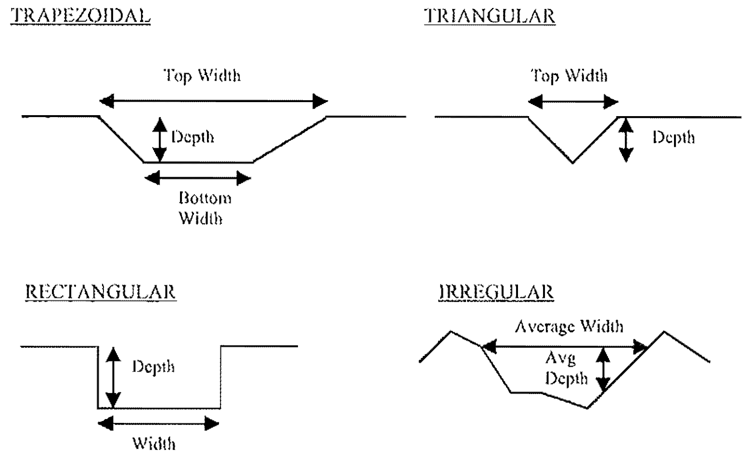
__X__ Cross-Valley
______ Side-Hill
______ Diked
______ Incised (form completion optional)
______ Combination Incised/Diked

Embankment Height _80__ feet   Embankment Material **Random earth shell with clay core**
Pool Area____420____ acres   Liner_**None**__________
Current Freeboard _26.8__ ft   Liner Permeability **NA**__________

TYPE OF OUTLET (Mark all that apply)

_____ **Open Channel Spillway**
Trapezoidal
______ Triangular
______ Triangular

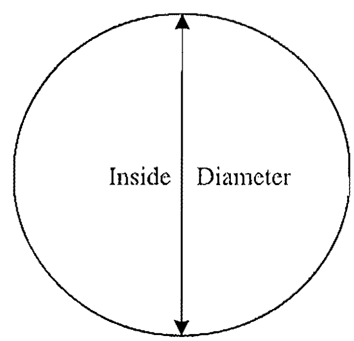
______ Depth
______ Bottom (or average) width
______ Top width



______ **Outlet**

______ inside diameter

Material
______ corrugated metal
______ welded steel
______ concrete
______ plastic (hdpe, pvc, etc.)
______ other (specify ________________



Is water flowing through the outlet? YES______ NO______

__X__ **No Outlet –**

______ **Other Type of Outlet (Specify)** ____

The Impoundment was Designed By **Ebasco Services, Inc.**

Has there ever been a failure at this site? YES ______ NO __X__

If So When? ____

If So Please Describe:

Has there ever been significant seepages at this site? YES __X__ NO______

If So When? **Monitored since 1993.**

If So Please Describe: **Several seepages have been identified in the dam foundation downstream of the toe. The seepages are monitored regularly and frequently. Cholla monitors the seepages mainly due to the environmental concerns associated with dam material entering into nearby waterways. Water is collected at these seepage locations and returned to the reservoir. The main seepages identified are listed below.**

Geronimo Seep: This seepage is located less than 50 feet beyond the downstream toe about 2000 feet from the right abutment. An underground French drain system and wellpoints have been installed to monitor and collect the seepage in this area This seepage is the nearest to the fly ash dam and is the most voluminous of the three major seeps and most likely the only one to influence dam stability. A maximum flow of 46.8 gpm has been measured at this seep since measurements began in November 1993. No flowing surface water was observed at the time of the dam assessment at this seep location. We will look closely at the data associated with this seep when we prepare our report to investigate whether it may negatively affect dam safety.

Hunt Seep: This seepage is located more than 1,500 feet beyond the downstream toe of the dam, across I-40. No flowing water was observed at the time of the dam assessment at this location. An underground French drain system is used to monitor and collect the seepage in this area. A maximum flow of 12.5 gpm has been measured at this seep since measurements began in March 1997.

I-40 Seep: This seepage is located less than 50 feet beyond the right abutment toe. Salt patches are visible and the soil at this location has been damp in the past, but no flowing surface water is associated with this seep.

Has there ever been any measures undertaken to monitor/lower Phreatic water table levels based on past seepages or breaches at this site? YES ______ NO__X___

If So which method (e.g., piezometers, gw pumping, …)? ______________________

If So Please Describe:

Site Name: **Cholla Generating Station, Joseph City, AZ** Date: **Sept 2, 2009**

Unit Name: **Bottom Ash Pond Dam** Operator's Name: **Arizona Public Service**

Unit ID: Hazard Potential Classification: **High** Significant Low

Inspector's Name: **Steve Townsley/GEI Consultants, Mary Nodine/GEI Consultants**

Check the appropriate box below, Provide comments when appropriate. If not applicable or not available, record "N/A", Any unusual conditions or construction practices that should be noted in the comments section, For large diked embankments, separate checklists may be used for different embankment areas. If separate forms are used, identify approximate area that the form applies to in comments.

	Yes	No		Yes	No
1. Frequency of Company's Dam Inspections?	Annual		18. Sloughing or bulging on slopes?		X
2. Pool elevation (operator records)?	5111.3		19. Major erosion or slope deterioration?		X
3. Decant inlet elevation (operator records)?	NA		20. Decant Pipes		
4. Open channel spillway elevation (operator records)?	NA		Is water entering inlet, but not exiting outlet?		X
5. Lowest dam crest elevation (operator records)?	5123.3		Is water exiting outlet, but not entering inlet?		X
6. If instrumentation is present, are readings recorded (operator records)?	X		Is water exiting outlet flowing clear?	NA	
7. Is the embankment currently under construction?		X	21. Seepage (specify location, if seepage carries fines, and approximate seepage rate below):		
8. Foundation preparation (remove vegetation, stumps, topsoil in area where embankment fill will be placed)?		X	From underdrain?		X
9. Trees growing on embankment? (If so, indicate largest diameter below.)		X	At isolated points on embankment slopes?		X
10. Cracks or scarps on crest?		X	At natural hillside in the embankment area?		X
11. Is there significant settlement along the crest?		X	Over widespread areas?		X
12. Are decant trashracks clear and in place?	NA		From downstream foundation area?	X	
13. Depressions or sink holes in tailings surface or whirlpool in the pool area		X	"Boils" beneath stream or ponded water?		X
14. Clogged spillways, groin or diversion ditches?		X	Around the outside of the decant pipe?		X
15. Are spillway or ditch linings deteriorated?		X	22. Surface movements in valley bottom or on hillside?		X
16. Are outlets of decant or underdrains blocked?		X	23. Water against downstream toe?		X
17. Cracks or scarps on slopes		X	24. Were Photos taken during the dam inspection?	X	

Major adverse changes in these items could cause instability and should be reported for further evaluation. Adverse conditions noted in these items should normally be described (extent, location, volume, etc.) in the space below and on the back of this sheet.

Inspection Issue #	Comments
21. Seepage locations beyond dam toe	See discussion page 7
9. Vegetation on upstream and downstream slopes	Brush should be cleared during routine maintenance
2. North pond cells are partially filled with bottom ash	Required freeboard should be calculated and maximum
and do not contribute to reservoir storage.	pool elevation revised based on reduced pond volume.

Coal Combustion Waste (CCW)
Impoundment Inspection

Impoundment NPDES Permit # **NA** INSPECTOR **Steve Townsley/GEI**

Date **Sept 2, 2009**

Impoundment Name **Bottom Ash Pond Dam, Cholla Generating Station, Joseph City, AZ**

Impoundment Company **Arizona Public Service**

EPA Region **6**

State Agency (Field Office) Address **2225 W. Peoria Avenue, Phoenix, AZ 85029-4929**

Name of Impoundment **Bottom Ash Pond Dam**
(Report each impoundment on a separate form under the same Impoundment NPDES Permit number)

New **X** Update ______

	Yes	No
Is impoundment currently under construction?		**X**
Is water or ccw currently being pumped into the impoundment?	**X**	

IMPOUNDMENT FUNCTION: **Bottom Ash and Decant Water Storage**

Nearest Downstream Town: Name **Joseph City**
Distance from the impoundment **2 miles**

Impoundment Location:						
Longitude	**34**	Degrees	**57**	Minutes	**22**	Seconds
Latitude	**110**	Degrees	**20**	Minutes	**5**	Seconds
State	**AZ**	County	**Navajo**			

Does a state agency regulate this impoundment? YES **X** NO ______

If So Which State Agency? **Arizona Department of Water Resources**

HAZARD POTENTIAL (In the event the impoundment should fail, the following would occur):

______ **LESS THAN LOW** HAZARD POTENTIAL: Failure or misoperation of the dam results in no probable loss of human life or economic or environmental losses.

______ **LOW HAZARD POTENTIAL:** Dams assigned the low hazard potential classification are those where failure or misoperation results in no probable loss of human life and low economic and/or environmental losses. Losses are principally limited to the owner's property.

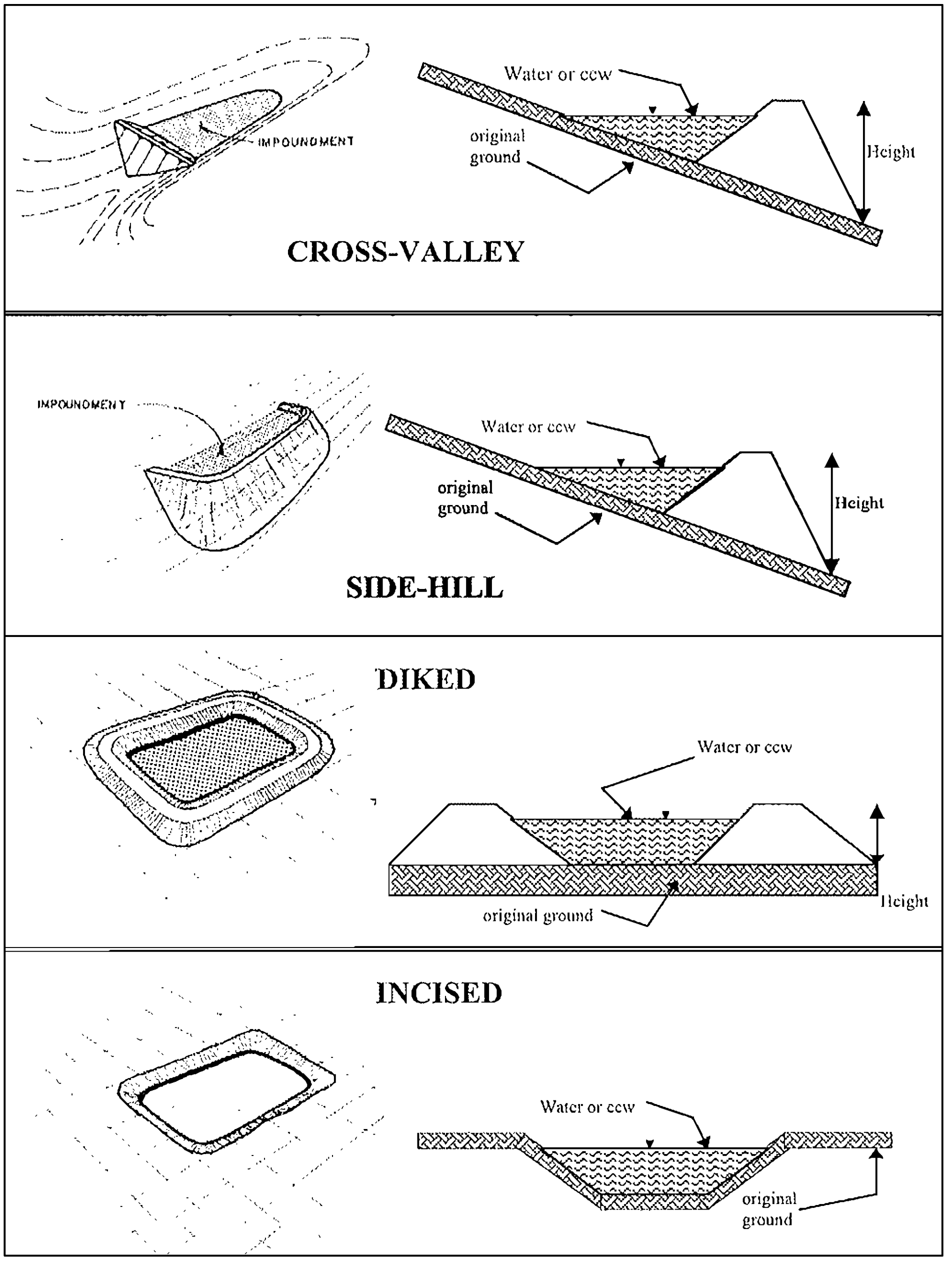
______ **SIGNIFICANT HAZARD POTENTIAL:** Dams assigned the significant hazard potential classification are those dams where failure or misoperation results in no probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities, or can impact other concerns. Significant hazard potential classification dams are often located in predominantly rural or agricultural areas but could be located in areas with population and significant infrastructure.

__X__ **HIGH HAZARD POTENTIAL:** Dams assigned the high hazard potential classification are those where failure or misoperation will probably cause loss of human life.

DESCRIBE REASONING FOR HAZARD RATING CHOSEN:

A failure of the dam may cause inundation of Interstate 40, a freight railroad line and the APS Cholla Power Plant, all located just downstream of the Bottom Ash Pond Dam. Flooding of these facilities would certainly cause significant economic losses and would likely cause loss of life.

CONFIGURATION:



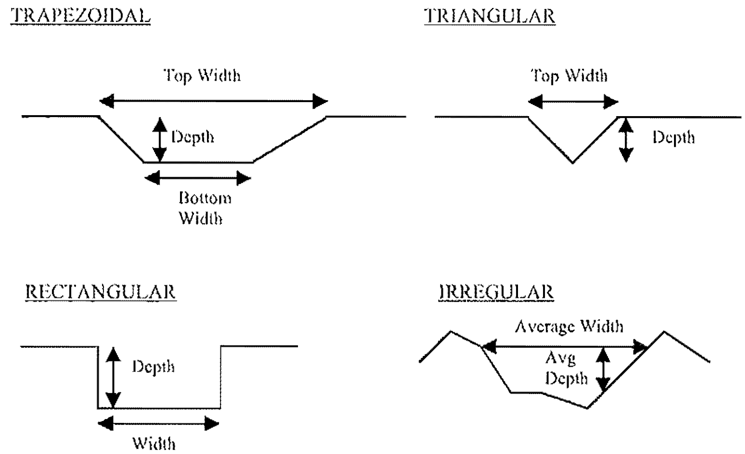
______ Cross-Valley
__X__ Side-Hill
______ Diked
______ Incised (form completion optional)
______ Combination Incised/Diked

Embankment Height _73__ feet   Embankment Material **Random earth shell with clay core**
Pool Area_____80_____ acres   Liner_**None**________________
Current Freeboard _12.0__ ft   Liner Permeability **NA**______________

TYPE OF OUTLET (Mark all that apply)

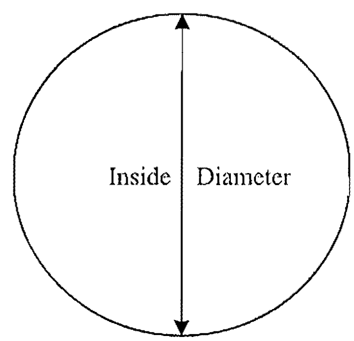
_____**Open Channel Spillway**
Trapezoidal
______ Triangular
______ Triangular

______Depth
______Bottom (or average) width
______Top width



__X (4)__ **Outlet**

__12 in__ inside diameter



Material
______ corrugated metal
______ welded steel
______ concrete
__X__ plastic (hdpe, pvc, etc.)
______ other (specify ________________

Is water flowing through the outlet? YES __X__ NO______

______**No Outlet –**

______ **Other Type of Outlet (Specify)** ____

The Impoundment was Designed By __Ebasco Services, Inc.__

Has there ever been a failure at this site? YES ______ NO __X__

If So When? ____________________

If So Please Describe:

Has there ever been significant seepages at this site? YES __X__ NO______

If So When? **Monitored since 1993.**

If So Please Describe: **Several seepages have been identified in the dam foundation downstream of the toe. The seepages are monitored regularly and frequently. Cholla monitors the seepages mainly due to the environmental concerns associated with dam material entering into nearby waterways. Water is collected at these seepage locations and returned to the reservoir. The main seepages identified are listed below.**

West Abutment Seep: This seepage is located about 100 feet downstream of the west abutment toe. APS Cholla monitors the flow that daylights in this area using a weir, in addition to measuring the quantity collected via a French drain system several hundred feet east along the face. Water was observed flowing through the weir at the time of our site visit, and a rough measurement indicated the flow at this time was less than 2 gpm. The quantity of flow measured in the weir was about 2.7 gpm the last time it was read in June 2009, and has been 5 gpm or less since readings began in January 1996, with the exception of readings in 2000 when the log indicates that the weir overflowed. The flow measured in the French drain has had a maximum of 15.8 gpm since measurements began in December 1995. Of the four seepages monitored by APS Cholla, the West Abutment Seep is the nearest to the Bottom Ash Dam and most likely the only one with potential to influence dam stability. We will look closely at the data associated with this seep when we prepare our report to investigate whether it may negatively affect dam safety.

Tanner Wash Seep: This seepage is located about 350 feet beyond the left abutment of the dam. Seepage is collected via an underground French drain system. The water collected is regularly tested for turbidity due to its proximity to Tanner Wash to the west, and no significant quantity of turbidity has been measured. Flowing surface water was observed at the location of this seep at the time of our assessment. A maximum flow of 15.2 gpm has been measured at this seep since measurements began in January 1994.

Petroglyph Seep: This seepage is located south of the Tanner Wash Seep, about 150

feet beyond the dam toe. It is also collected by an underground French drain system. Flowing surface water was observed at the location of this seep at the time of our assessment. A maximum flow of 12.6 gpm has been measured at this seep since measurements began in December 1993.

P-226 Seep: This seepage is located about 250 feet beyond the left abutment toe. Seepage is collected by an underground French drain system. No surface water was present at this seep at the time of our site visit, and no flow has been measured in this seep since March of 2008. A maximum flow of 27.1 gpm has been measured at this seep since measurements began in December 1993.

Has there ever been any measures undertaken to monitor/lower Phreatic water table levels based on past seepages or breaches at this site? YES ______ NO__X___

If So which method (e.g., piezometers, gw pumping, …)? ______________________

If So Please Describe: ____

Appendix C

Inspection Photographs

September 2, 2009

Photo 1 –Fly Ash Pond: Overview looking north from embankment. Note downstream fly ash beach.

Photo 2 –Fly Ash Pond Dam: Crest of embankment with dirt road, looking east.

Photo 3- Movement monument on Fly Ash Pond Dam.

Photo 4 –Crest of Fly Ash Pond Dam with piezometer, looking east at bend in embankment.

Photo 5 –Fly Ash Pond Dam: Upstream slope, looking west. Note vegetation.

Photo 6 – Fly Ash Pond Dam: Slurry discharge point on upstream face.

Photo 7 – Fly Ash Pond Dam: Downstream slope, looking west. Note vegetation and riprap erosion.

Photo 8 – Fly Ash Pond Dam: Slurry pipes on downstream face.

Photo 9 – Bottom Ash Pond: Main reservoir, looking southwest from left abutment.

Photo 10 – Bottom Ash Pond: Main Reservoir, looking west along upstream face of dam.

Photo 11 – Bottom Ash Pond: East cell with drained bottom ash. Note construction operations moving bottom ash to monofill.

Photo 12 – Bottom Ash Pond: West cell, which is currently being filled with bottom ash slurry. Note vortex through which water flows to main reservoir.

Photo 13 – Bottom Ash Pond: Monofill for final storage of drained bottom ash.

Photo 14 – Bottom Ash Pond: Drainage way for overflow water from upstream cells to main reservoir.

Photo 15 – Bottom Ash Pond Dam: Crest of embankment with dirt road, looking west.

Photo 16 – Bottom Ash Pond Dam: Crest near left abutment with dam raise visible.

Photo 17 – Bottom Ash Pond Dam: Upstream slope, looking east. Note vegetation.

Photo 18 – Bottom Ash Pond: Downstream slope looking west. Note vegetation and riprap erosion

Photo 19 – Fly Ash Pond: Salt patch associated with seepage near right abutment toe (known as the "Hoodoo Salt Patch").

Photo 20 – Fly Ash Pond: Tamarisks near downstream toe indicating seepage.

Photo 21 – Fly Ash Pond: Evaporation Pond for I-40 Seep.

Photo 22 – Fly Ash Pond: Seepage collection system for Gironimo Seep.

Photo 23 – Fly Ash Pond: Seepage collection system for Gironimo Seep.

Photo 24 – Fly Ash Pond: Hunt Seep area. Note seepage collection system on left.

Photo 25 – Bottom Ash Pond: West Abutment Seep from embankment crest. Siphon pipes (center) and siphon collection system (lower left) are also visible.

Photo 26 – Bottom Ash Pond: Weir at West Abutment Seep.

Photo 27 – Bottom Ash Pond: Seepage collection system at West Abutment Seep.

Photo 28 – Bottom Ash Pond: Overview of West Abutment Seep area, looking from weir east toward seepage collection sump.

Photo 29 – Bottom Ash Pond: Seepage collection system for Tanner Wash Seep.

Photo 30 – Bottom Ash Pond: Salt patches at Tanner Wash Seep.

Photo 31 – Bottom Ash Pond: Flowing surface water at Tanner Wash Seep.

Photo 32 – Bottom Ash Pond: Tanner Wash.

Photo 33 – Bottom Ash Pond: Seepage collection system for Petroglyph Seep.

Photo 34 – Bottom Ash Pond: Flowing surface water at Petroglyph Seep.

Photo 35 – Fly Ash Pond: Buoy marking 300-foot distance from area where cracks were observed in embankment crest. Fly ash beach must extend upstream of this distance.

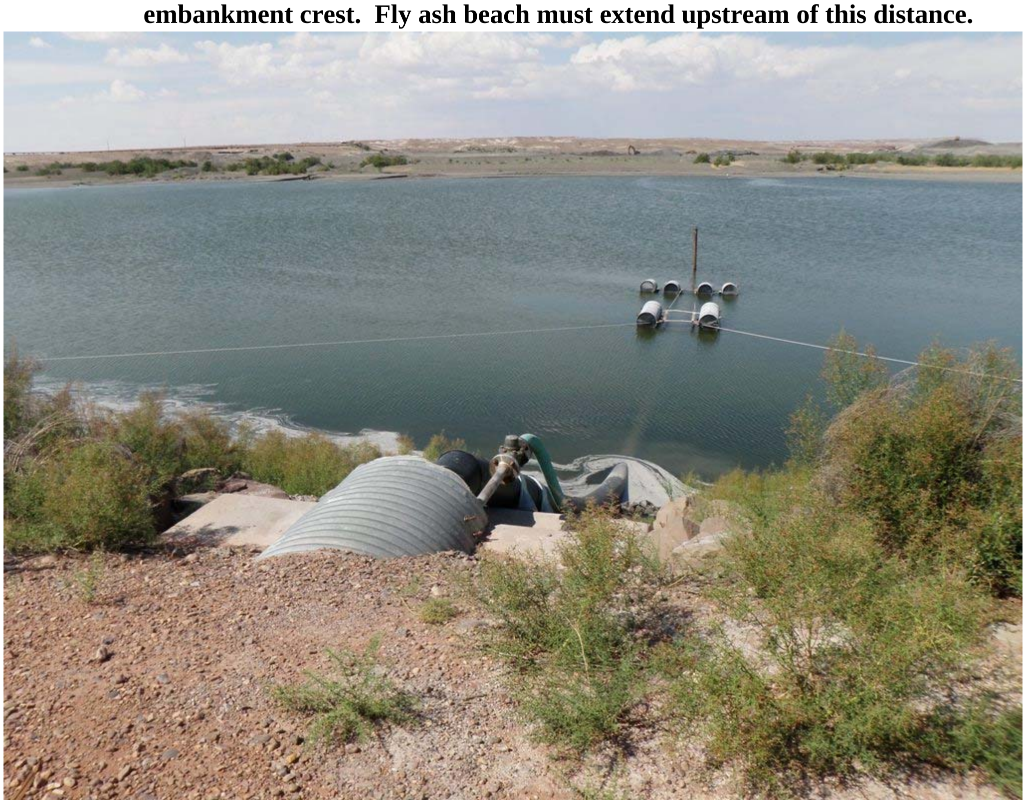


Photo 36 – Bottom Ash Pond: Floating siphon pipes to return water from main reservoir to power plant – upstream side of dam.

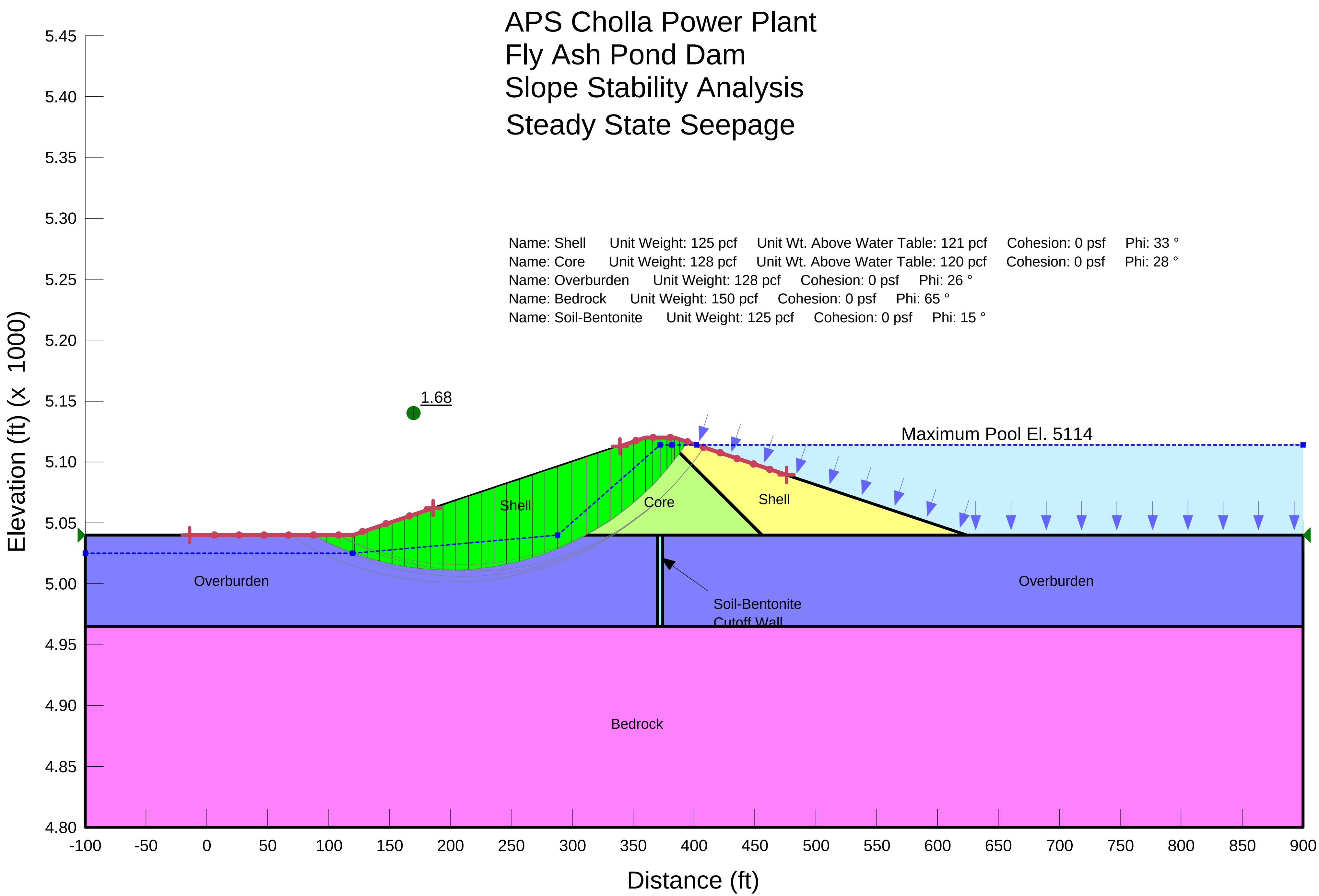
Photo 37 – Bottom Ash Pond: Siphon pipes extending along downstream slope of dam.

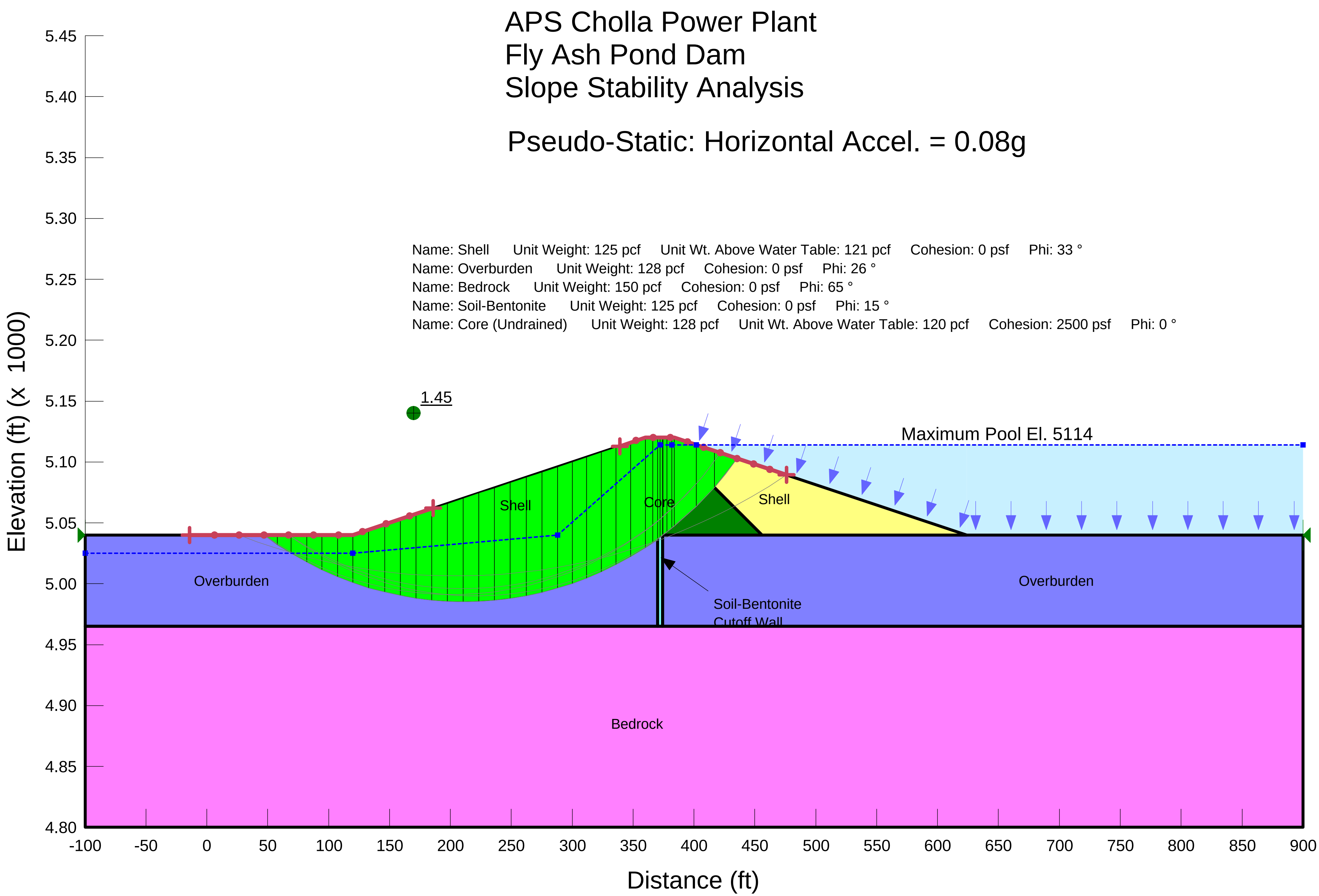
Photo 38 – Bottom Ash Pond: Siphon collection station at toe of dam.

Photo 39 – Bottom Ash Pond: Siphon pipes extending along downstream slope, and siphon collection station.

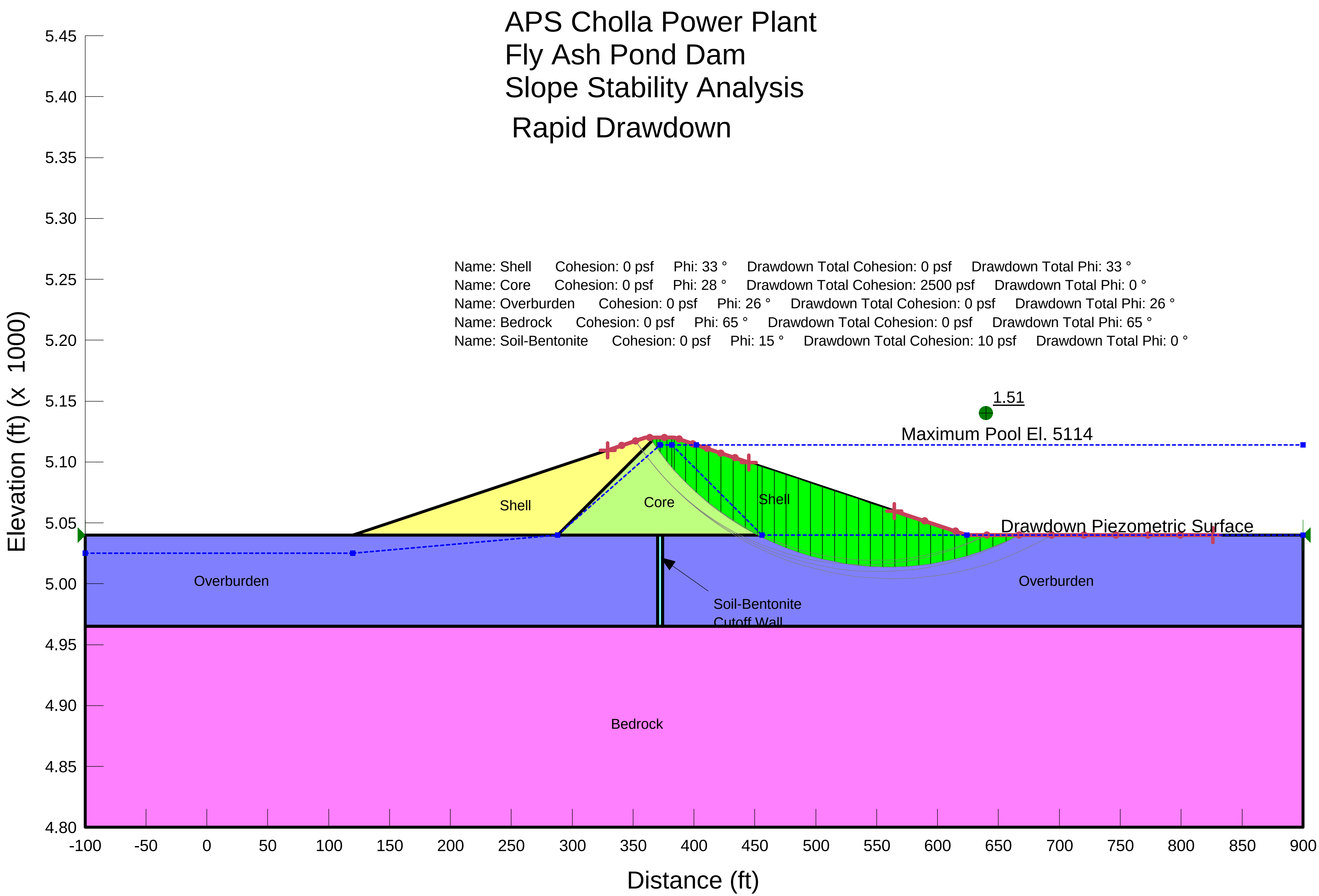
Appendix D

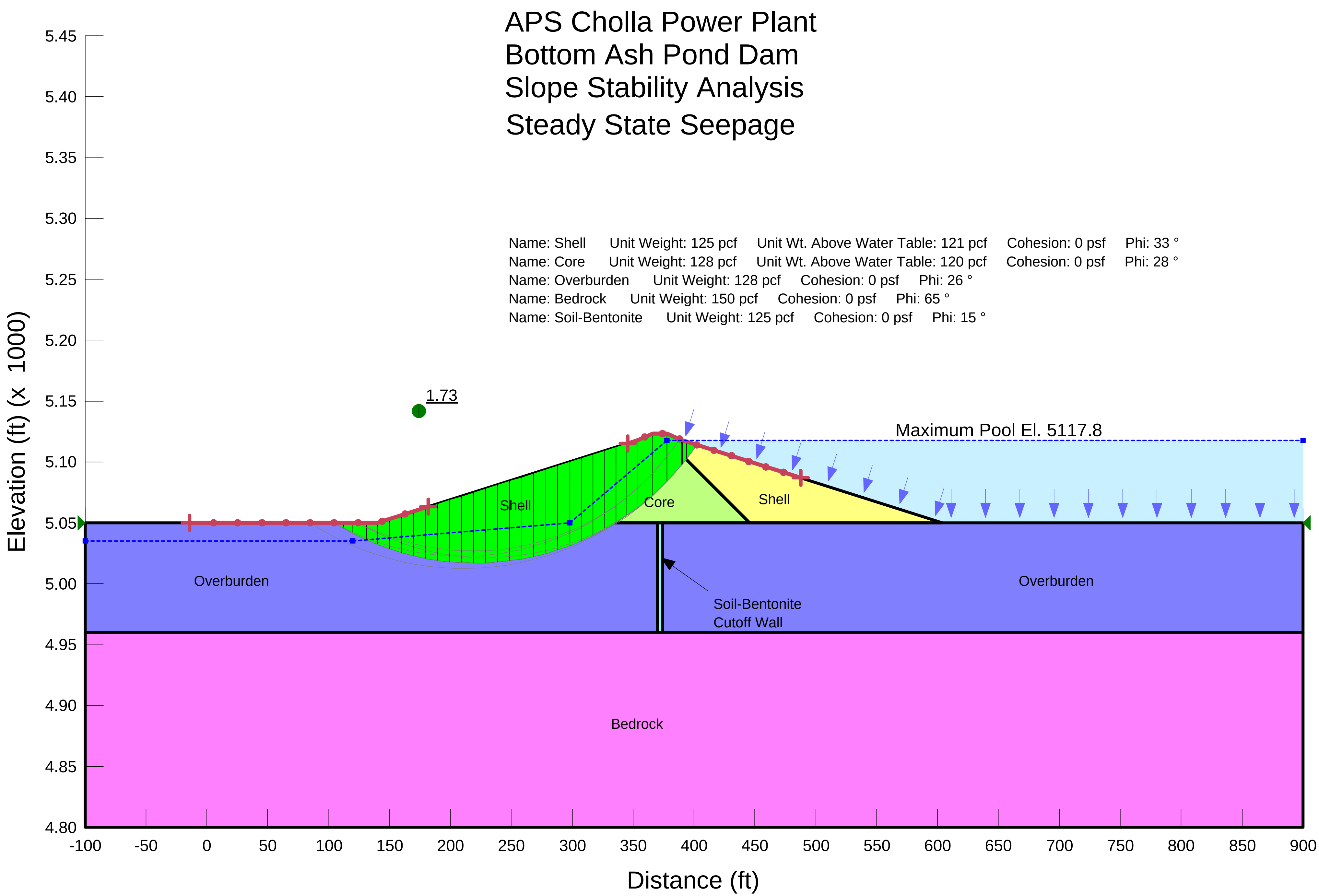
Stability Analyses

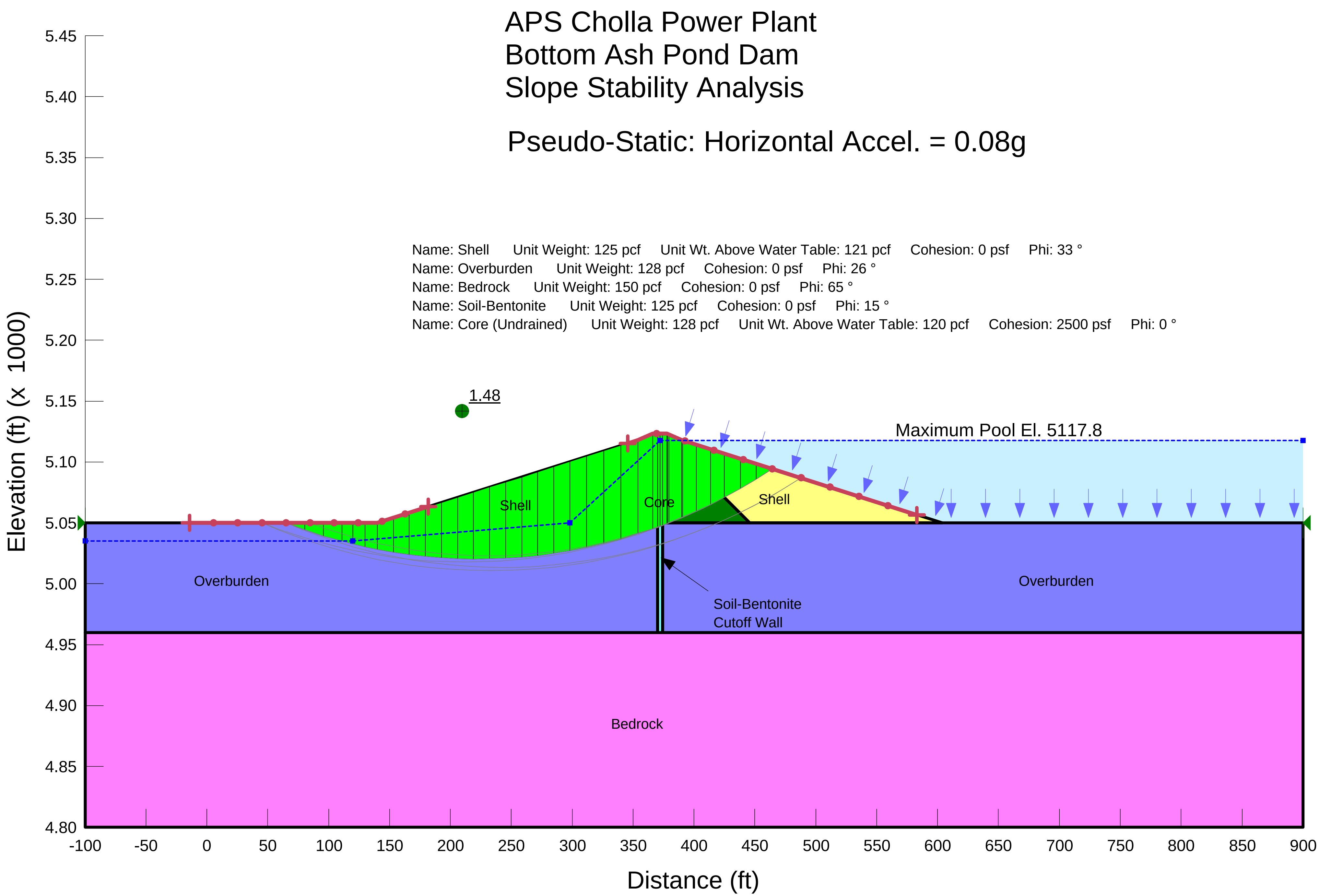

APS Cholla Power Plant
Fly Ash Pond Dam
Slope Stability Analysis
Steady State Seepage
Name: Shell Unit Weight: 125 pcf Unit Wt. Above Water Table: 121 pcf Cohesion: 0 psf Phi: 33 °
Name: Core Unit Weight: 128 pcf Unit Wt. Above Water Table: 120 pcf Cohesion: 0 psf Phi: 28 °
Name: Overburden Unit Weight: 128 pcf Cohesion: 0 psf Phi: 26 °
Name: Bedrock Unit Weight: 150 pcf Cohesion: 0 psf Phi: 65 °
Name: Soil-Bentonite Unit Weight: 125 pcf Cohesion: 0 psf Phi: 15 °
1.68
Maximum Pool El. 5114
Shell
Core
Shell
Overburden
Overburden
Soil-Bentonite
Cutoff Wall
Bedrock
Elevation (ft) (x 1000)
5.45
5.40
5.35
5.30
5.25
5.20
5.15
5.10
5.05
5.00
4.95
4.90
4.85
4.80
-100 -50 0 50 100 150 200 250 300 350 400 450 500 550 600 650 700 750 800 850 900
Distance (ft)



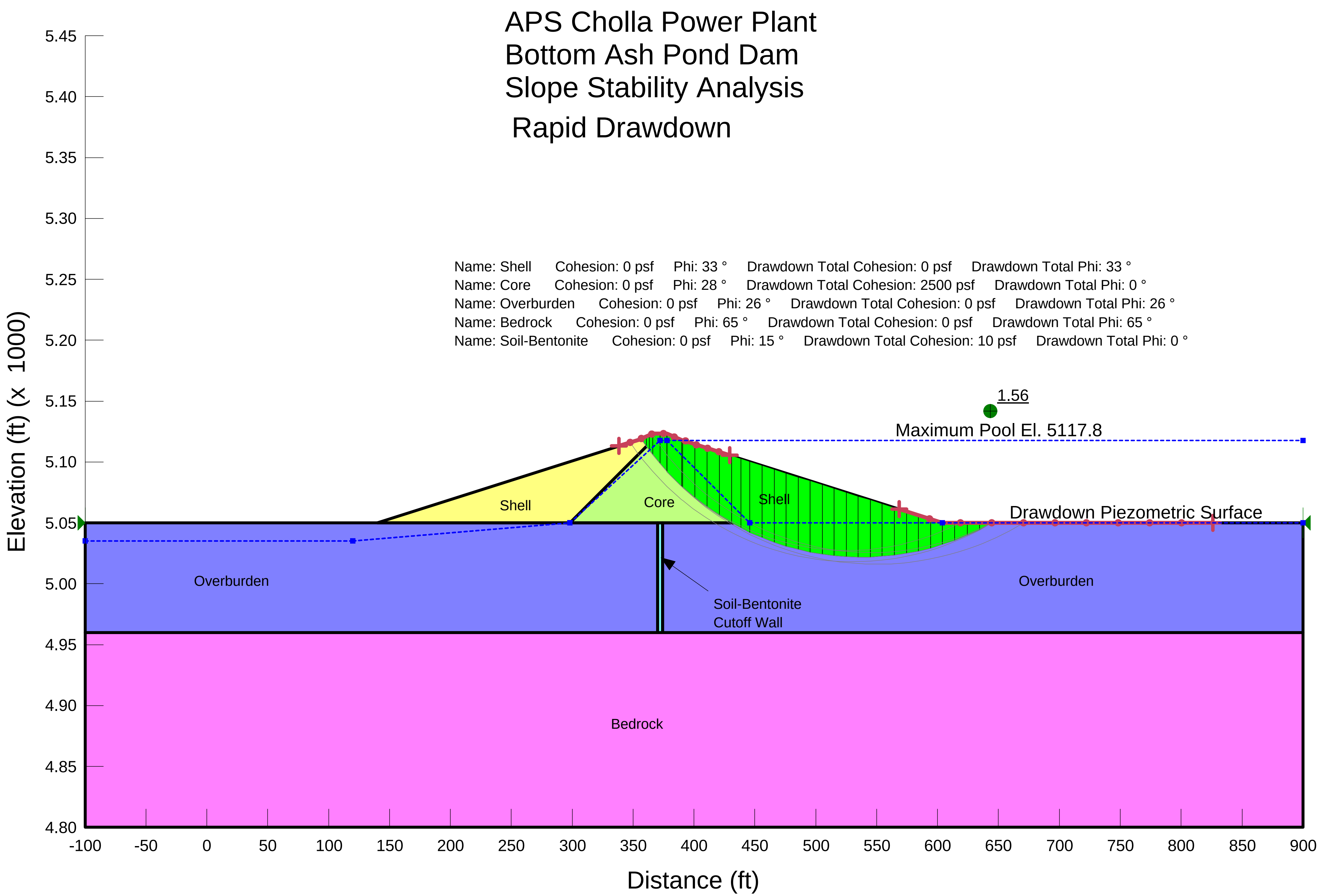
APS Cholla Power Plant
Fly Ash Pond Dam
Slope Stability Analysis
Pseudo-Static: Horizontal Accel. = 0.08g
Name: Shell Unit Weight: 125 pcf Unit Wt. Above Water Table: 121 pcf Cohesion: 0 psf Phi: 33 °
Name: Overburden Unit Weight: 128 pcf Cohesion: 0 psf Phi: 26 °
Name: Bedrock Unit Weight: 150 pcf Cohesion: 0 psf Phi: 65 °
Name: Soil-Bentonite Unit Weight: 125 pcf Cohesion: 0 psf Phi: 15 °
Name: Core (Undrained) Unit Weight: 128 pcf Unit Wt. Above Water Table: 120 pcf Cohesion: 2500 psf Phi: 0 °
1.45
Maximum Pool El. 5114
Shell
Core
Shell
Overburden
Overburden
Soil-Bentonite
Cutoff Wall
Bedrock
Elevation (ft) (x 1000)
5.45
5.40
5.35
5.30
5.25
5.20
5.15
5.10
5.05
5.00
4.95
4.90
4.85
4.80
-100
-50
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
850
900
Distance (ft)


APS Cholla Power Plant
Fly Ash Pond Dam
Slope Stability Analysis
Rapid Drawdown
Name: Shell Cohesion: 0 psf Phi: 33 ° Drawdown Total Cohesion: 0 psf Drawdown Total Phi: 33 °
Name: Core Cohesion: 0 psf Phi: 28 ° Drawdown Total Cohesion: 2500 psf Drawdown Total Phi: 0 °
Name: Overburden Cohesion: 0 psf Phi: 26 ° Drawdown Total Cohesion: 0 psf Drawdown Total Phi: 26 °
Name: Bedrock Cohesion: 0 psf Phi: 65 ° Drawdown Total Cohesion: 0 psf Drawdown Total Phi: 65 °
Name: Soil-Bentonite Cohesion: 0 psf Phi: 15 ° Drawdown Total Cohesion: 10 psf Drawdown Total Phi: 0 °
1.51
Maximum Pool El. 5114
Drawdown Piezometric Surface
Shell
Core
Shell
Overburden
Overburden
Soil-Bentonite
Cutoff Wall
Bedrock
Elevation (ft) (x 1000)
5.45
5.40
5.35
5.30
5.25
5.20
5.15
5.10
5.05
5.00
4.95
4.90
4.85
4.80
-100
-50
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
850
900
Distance (ft)


APS Cholla Power Plant
Bottom Ash Pond Dam
Slope Stability Analysis
Steady State Seepage
Name: Shell Unit Weight: 125 pcf Unit Wt. Above Water Table: 121 pcf Cohesion: 0 psf Phi: 33 °
Name: Core Unit Weight: 128 pcf Unit Wt. Above Water Table: 120 pcf Cohesion: 0 psf Phi: 28 °
Name: Overburden Unit Weight: 128 pcf Cohesion: 0 psf Phi: 26 °
Name: Bedrock Unit Weight: 150 pcf Cohesion: 0 psf Phi: 65 °
Name: Soil-Bentonite Unit Weight: 125 pcf Cohesion: 0 psf Phi: 15 °
1.73
Maximum Pool El. 5117.8
Shell
Core
Shell
Overburden
Overburden
Soil-Bentonite
Cutoff Wall
Bedrock
Elevation (ft) (x 1000)
5.45
5.40
5.35
5.30
5.25
5.20
5.15
5.10
5.05
5.00
4.95
4.90
4.85
4.80
-100
-50
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
850
900
Distance (ft)



APS Cholla Power Plant
Bottom Ash Pond Dam
Slope Stability Analysis
Pseudo-Static: Horizontal Accel. = 0.08g
Name: Shell Unit Weight: 125 pcf Unit Wt. Above Water Table: 121 pcf Cohesion: 0 psf Phi: 33 °
Name: Overburden Unit Weight: 128 pcf Cohesion: 0 psf Phi: 26 °
Name: Bedrock Unit Weight: 150 pcf Cohesion: 0 psf Phi: 65 °
Name: Soil-Bentonite Unit Weight: 125 pcf Cohesion: 0 psf Phi: 15 °
Name: Core (Undrained) Unit Weight: 128 pcf Unit Wt. Above Water Table: 120 pcf Cohesion: 2500 psf Phi: 0 °
1.48
Maximum Pool El. 5117.8
Shell
Core
Shell
Overburden
Overburden
Soil-Bentonite
Cutoff Wall
Bedrock
Elevation (ft) (x 1000)
Distance (ft)
5.45
5.40
5.35
5.30
5.25
5.20
5.15
5.10
5.05
5.00
4.95
4.90
4.85
4.80
-100
-50
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
850
900



APS Cholla Power Plant
Bottom Ash Pond Dam
Slope Stability Analysis
Rapid Drawdown
Name: Shell Cohesion: 0 psf Phi: 33 ° Drawdown Total Cohesion: 0 psf Drawdown Total Phi: 33 °
Name: Core Cohesion: 0 psf Phi: 28 ° Drawdown Total Cohesion: 2500 psf Drawdown Total Phi: 0 °
Name: Overburden Cohesion: 0 psf Phi: 26 ° Drawdown Total Cohesion: 0 psf Drawdown Total Phi: 26 °
Name: Bedrock Cohesion: 0 psf Phi: 65 ° Drawdown Total Cohesion: 0 psf Drawdown Total Phi: 65 °
Name: Soil-Bentonite Cohesion: 0 psf Phi: 15 ° Drawdown Total Cohesion: 10 psf Drawdown Total Phi: 0 °
1.56
Maximum Pool El. 5117.8
Drawdown Piezometric Surface
Shell
Core
Shell
Overburden
Overburden
Soil-Bentonite
Cutoff Wall
Bedrock
Elevation (ft) (x 1000)
5.45
5.40
5.35
5.30
5.25
5.20
5.15
5.10
5.05
5.00
4.95
4.90
4.85
4.80
-100
-50
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
850
900
Distance (ft)

Appendix E

Reply to Request for Information Under Section 104(e)

THE POWER TO MAKE IT HAPPEN℠

John R. Denman
Senior Vice President
Fossil

Tel. 602-250-3220
Fax 602-250-3902
jdenman@apsc.com

Mail Station 9046
PO Box 53999
Phoenix, Arizona 85072-3999

VIA FEDERAL EXPRESS

March 26, 2009

Mr. Richard Kinch
U.S. Environmental Protection Agency
5th Floor N-5783
Two Potomac Yard
2733 S. Crystal Drive
Arlington, Virginia 22202-2733

Re: Arizona Public Service Company – Cholla Generating Station: Request for Information Under 104(e) of the Comprehensive Environmental Response, Compensation, and Liability Act, 42 U.S.C. 9604(e) ("104(e) Request").

Dear Mr. Kinch:

On March 13, 2009, Arizona Public Service Company ("APS") received the above referenced 104(e) Request for each surface impoundment or similar diked or bermed management unit(s) or management units designated as landfills at the Cholla Generating Station which receive liquid-borne material for the storage or disposal of residuals or by-products from the combustion of coal, including, but not limited to, fly ash, bottom ash, boiler slag, or flue gas emission control residuals. APS's response for the Cholla Generating Station is attached.

I certify that the information contained in this response to EPA's request for information and the accompanying documents is true, accurate, and complete. As to the identified portions of this response for which I cannot personally verify their accuracy, I certify under penalty of law that this response and all attachments were prepared in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fines and imprisonment for knowing violations.

Signature: John R Denman
Name: John R. Denman
Title: Sr. V.P., Fossil Generation

Arizona Public Service Company's 104(e) Response for the Cholla Generating Station

Plant Description

The Cholla Generating Station is a four unit, coal fired, 1160 megawatt steam electric power plant. As part of its operations, the plant generates residuals and by-products from the combustion of coal. The residuals and by-products are conveyed to four surface impoundments for storage and disposal: a Bottom Ash Pond, a Fly Ash Pond, a Sedimentation Pond, and a retention pond named the West Area Retention Pond. Approximately 70% of the fly ash generated at the plant is sold for beneficial reuse.

Impoundment Descriptions

Bottom Ash Pond

The Bottom Ash Pond is a zoned clay core earthen embankment, which receives bottom ash (slurried with process water) from all four of the plant's generating units. The bottom ash settles to the bottom of the Bottom Ash Pond, and the process water is siphoned back to the general water sump and re-used.

Fly Ash Pond

The Fly Ash Pond is a zoned clay core earthen embankment (with a ten foot by 650 foot saddle dike), which receives fly ash from all four of the plant's generating units.

Fabric filters remove dry fly ash from generating units 1, 3, and 4. Generating unit 2 uses a mechanical dust collector to remove some fly ash on a dry basis, and a venturi scrubber system (a wet particulate/ SO_2 removal system) removes additional fly ash. The dry fly ash that is not sold for beneficial re-use and all of the wet fly ash are slurried with flue gas desulfurization residuals and pumped to the fly ash pond.

Sedimentation Pond

The Sedimentation Pond is a sub-grade impoundment, with a two foot thick compacted clay liner, which receives *de minimis* amounts of coal combustion by-products in storm water, process water, plant wash down water, and slurry from system leaks, from drains located on the plant site.

West Area Retention Pond

The West Area Retention Pond is a sub-grade impoundment, with an earthen liner, which receives *de minimis* amounts of coal combustion by-products in storm water, process water, and plant wash down water, from the west side of the plant.

104(e) Questions

Please provide the information requested below for each surface impoundment or similar diked or bermed management unit(s) or management units designated as landfills which receive liquid-borne material for the storage or disposal of residuals or by-products from the combustion of coal, including, but not limited to, fly ash, bottom ash, boiler slag, or flue gas emission control residuals. This includes units that no longer receive coal combustion residues or by-products, but still contain free liquids.

1. Relative to the National Inventory of Dams criteria for High, Significant, Low, or Less than Low Hazard Potential, please provide the potential hazard rating for each management unit and indicate who established the rating, what the basis for the rating is, and what federal or state agency regulates the unit(s) . If the unit(s) does not have a rating, please note that fact.

Bottom Ash Pond

The rating, which is designated by the Arizona Department of Water Resources, Dam Safety and Flood Mitigation Division, which regulates the unit, is "High Hazard Potential." The basis for the rating is set forth in the Arizona Administrative Code ("A.A.C."), Article 12. Dam Safety Procedures, Section R12-15-1206 B, attached to this response as Exhibit A (Section R12-15-1202, which contains the definitions of the terms "Hazard potential" and Hazard potential classification," is also attached as part of Exhibit A).

Fly Ash Pond

The rating, which is designated by the Arizona Department of Water Resources, Dam Safety and Flood Mitigation Division, which regulates the unit, is "High Hazard Potential." The basis for the rating is set forth in the A.A.C., Article 12. Dam Safety Procedures, Section R12-15-1206 B, attached to this response as Exhibit A (Section R12-15-1202, which contains the definitions of the terms "Hazard potential" and Hazard potential classification," is also attached as part of Exhibit A).

Sedimentation Pond

Because the Sedimentation Pond does not meet the definition of a dam, as set forth in the Arizona Revised Statutes § 45-1201(1), the unit is not regulated as a dam.

West Area Retention Pond

Because the West Area Retention Pond does not meet the definition of a dam, as set forth in the Arizona Revised Statutes § 45-1201(1), the unit is not regulated as a dam.

2. What year was each management unit commissioned and expanded?

Bottom Ash Pond

Commissioned (in-service) in 1978. Expanded in 1991.

Fly Ash Pond

Commissioned (in-service) in 1978.

Sedimentation Pond

Commissioned (in-service) in 1976

West Area Retention Pond

Commissioned (in-service) in 2002.

3. What materials are temporarily or permanently contained in the unit? Use the following categories to respond to this question: (1) fly ash; (2) bottom ash: (3) boiler slag; (4) flue gas emission control residuals; (5) other. If the management unit contains more than one type of material, please identify all that apply. Also, if you identify "other," please specify the other types of materials that are temporarily or permanently contained in the unit(s).

Bottom Ash Pond

(1) Fly ash ; (2) bottom ash; (3) boiler slag; (4) flue gas emission control residuals; and (5) other. Other types include: sedimentation pond effluent, sedimentation pond solids, cooling tower blowdown, oil/water separators effluent, oil/water separator solids, boiler cleaning wastes, and storm water.

Fly Ash Pond

(1) Fly ash; (2) bottom ash; (3) boiler slag; (4) flue gas emission control residuals; and (5) other. Other types include: storm water, sedimentation pond solids, boiler cleaning wastes, and oil/water separator solids.

Sedimentation Pond

(1) Fly ash (*de minimis* amounts); (2) bottom ash (*de minimis* amounts); (3) boiler slag (*de minimis* amounts); (4) flue gas emission control residuals (*de minimis* amounts); and (5) other. Other types include: discharges of domestic wastewater from the secondary wastewater treatment plant, effluent from the oil/water separator, storm water, and vehicle wash water from the spray wash station.

West Area Retention Pond

(1) Fly ash (*de minimis* amounts); (2) bottom ash (*de minimis* amounts); (3) boiler slag (*de minimis* amounts); (4) flue gas emission control residuals (*de minimis* amounts); and (5) other (storm water).

4. Was the management unit(s) designed by a Professional Engineer? Is or was the construction of the waste management unit(s) under the supervision of a Professional Engineer? Is inspection and monitoring of the safety of the waste management unit(s) under the supervision of a Professional Engineer?

Bottom Ash Pond

The Bottom Ash Pond was designed by a Professional Engineer. Its construction was under the supervision of a Professional Engineer. Inspection and monitoring of the safety of the Bottom Ash Pond is under the supervision of a Professional Engineer.

Fly Ash Pond

The Fly Ash Pond was designed by a Professional Engineer. Its construction was under the supervision of a Professional Engineer. Inspection and monitoring of the safety of the Fly Ash Pond is under the supervision of a Professional Engineer.

Sedimentation Pond

The Sedimentation Pond was designed by a Professional Engineer. Its construction was under the supervision of a Professional Engineer. Inspection and monitoring of the safety of the Sedimentation Pond is not under the supervision of a Professional Engineer.

West Area Retention Pond

The West Area Retention Pond was designed by a Professional Engineer. Its construction was under the supervision of a Professional Engineer. Inspection and monitoring of the safety of the West Area Retention Pond is not under the supervision of a Professional Engineer.

5. When did the company last assess or evaluate the safety (i.e., structural integrity) of the management unit(s)? Briefly describe the credentials of those conducting the structural integrity assessments/evaluations. Identify actions taken or planned by facility personnel as a result of these assessments or evaluations. If corrective actions were taken, briefly describe the credentials of those performing the corrective actions, whether they were company employees or contractors. If the company plans an assessment or evaluation in the future, when is it expected to occur?

Bottom Ash Pond

APS last assessed or evaluated the safety of the Bottom Ash Pond on May 8-9, 2008. The individual who conducted the assessment/evaluation was an APS Generation Engineering, Civil and Structural Engineer (P.E.). No safety deficiencies were identified. The next assessment/evaluation is scheduled for May 2009.

Note that APS's assessment/evaluation included an examination of dessication cracks in the crest of the embankment of the Bottom Ash Pond (above the water line). These cracks were observed during the Arizona Department of Water Resources, Dam Safety and Flood Mitigation Division's ("ADWR") 2007 inspection, at which time, ADWR did not designate the cracks as a safety deficiency. The cracks were also noted in ADWR's 2008 inspection report, which also indicated that there were no safety deficiencies found during the inspection.

APS has determined that the cracks are shallow and do not represent a safety issue, and APS is working with ADWR to close out the evaluation.

Fly Ash Pond

APS last assessed or evaluated the safety of the Fly Ash Pond on May 8-9, 2008. The individual who conducted the assessment/evaluation was an APS Generation Engineering, Civil and Structural Engineer (P.E.). No safety deficiencies were identified. The next assessment/evaluation is scheduled for May 2009.

Sedimentation Pond

Because the Sedimentation Pond does not meet the definition of a dam, as set forth in the Arizona Revised Statutes § 45-1201(1), safety assessments/evaluations are not necessary for this sort of structure.

West Area Retention Pond

Because the West Area Retention Pond does not meet the definition of a dam, as set forth in the Arizona Revised Statutes § 45-1201(1), safety assessments/evaluations are not necessary for this sort of structure.

6. When did a State or a Federal regulatory official last inspect or evaluate the safety (structural integrity) of the management unit(s)? If you are aware of a planned state or federal inspection or evaluation in the future, when is it expected to occur? Please identify the Federal or State regulatory agency or department which conducted or is planning the inspection or evaluation. Please provide a copy of the most recent official inspection report or evaluation.

Bottom Ash Pond

The Arizona Department of Water Resources, Dam Safety and Flood Mitigation Division, last inspected the Bottom Ash Pond on September 24-25, 2008. The next planned inspection is scheduled for September 2009. A copy of the most recent official inspection report is attached as Exhibit B.

Fly Ash Pond

The Arizona Department of Water Resources, Dam Safety and Flood Mitigation Division, last inspected the Fly Ash Pond on September 24-25, 2008. The next planned inspection is scheduled for September 2009. A copy of the most recent official inspection report is attached as Exhibit C.

Sedimentation Pond

Because the Sedimentation Pond does not meet the definition of a dam, as set forth in the Arizona Revised Statutes § 45-1201(1), safety inspections are not conducted.

West Area Retention Pond

Because the West Area Retention Pond does not meet the definition of a dam, as set forth in the Arizona Revised Statutes § 45-1201(1), safety inspections are not conducted.

7. Have assessments or evaluations, or inspections conducted by State or Federal regulatory officials conducted within the past year uncovered a safety issue(s) with the management unit(s), and, if so, describe the actions that have been or are being taken to deal with the issue or issues. Please provide any documentation that you have for these actions.

Bottom Ash Pond

No.

Fly Ash Pond

No.

Sedimentation Pond

Not applicable. See response to Question #6.

West Area Retention Pond

Not applicable. See response to Question #6.

8. What is the surface area (acres) and total storage capacity of each of the management units? What is the volume of material currently stored in each of the management unit(s). Please provide the date that the volume measurement(s) was taken. Please provide the maximum height of the management units(s). The basis for determining maximum height is explained later in this Enclosure.

Bottom Ash Pond

Surface area: 80 surface acres.

Total storage capacity: 2,300 acre feet.

Volume of materials currently stored: APS estimates that the Bottom Ash Pond currently holds 1,440 acre feet of bottom ash. This number is based on annual calculations of ash disposed of, which are performed as part of the annual Toxic Release Inventory Reporting submissions. The plant does not take physical measurements of volume.

Date volume measurement was taken: N/A (see explanation above).

The statutory dam height, established by the Arizona Department of Water Resources, Dam Safety and Flood Mitigation Division, is 73 feet.

Fly Ash Pond

Surface area: 420 surface acres.

Total storage capacity: 18,000 acre feet.

Volume of materials currently stored: APS estimates that the Fly Ash Pond currently holds 4,415 acre feet of material. This number is based on annual calculations of ash disposed of, which are performed as part of the annual Toxic Release Inventory Reporting submissions. The plant does not take physical measurements of volume.

Date volume measurement was taken: N/A (see explanation above).

The statutory dam height, established by the Arizona Department of Water Resources, Dam Safety and Flood Mitigation Division, is 80 feet.

Sedimentation Pond

Surface area: 1/2 surface acre.

Total storage capacity: 10.7 acre feet.

Volume of materials currently stored: 0.5 acre feet.

Date volume measurement was taken: March 19, 2009 (visual observation of sedimentation).

Dam height: N/A

West Area Retention Pond

Surface area: 1/4 surface acres.

Total storage capacity: 4.6 acre feet.

Volume of materials currently stored: Negligible.

Date volume measurement was taken: 03/19/09 (visual observation of sedimentation).

Dam height: N/A

9. Please provide a brief history of known spills or unpermitted releases from the unit within the last ten years, whether or not these were reported to State or federal regulatory agencies. For purposes of this question, please include only releases to surface water or to the land (do not include releases to groundwater).

APS's responses below do not include permitted releases.

Bottom Ash Pond

There have been no known spills or unpermitted releases within the last ten years.

Fly Ash Pond

There have been no known spills or unpermitted releases within the last ten years.

Sedimentation Pond

There have been no known spills or unpermitted releases within the last ten years.

West Area Retention Pond

There have been no known spills or unpermitted releases within the last ten years.

10. Please identify all current legal owner(s) and operator(s) at the facility.

For all four facilities, APS and PacifCorp are the owners, and APS is the operator.